MACHINERY.

January, 1907.

MECHANICAL CALCULATIONS AND DATA FOR DYNAMO DESIGN.

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IN the laying out of a dynamo the first thing to follow is the electrical data given, *i. e.*, the dimensions for armature core, field poles, windings, etc. As these generally are furnished beforehand to the mechanical designer, we will not enter into details how to obtain the same. But the mechanical part of the dynamo design is just as important, as upon that depends to a great extent the cost, efficiency and appearance of the machine. The aim of this article will be to give methods and data for properly dimensioning some parts of the dynamo.

Frame.—For direct-current dynamos the cross-section of the frame is always given and it may be considered safe as to the strength for frames up to an outside diameter of 8 feet. For larger direct-current and alternating-current machines the frame is to be carefully laid out and its deflection figured, so as to be sure that the cross-section is large enough. The following formula, derived from tests, is used for this. See Fig. 1:

$$D = 0.05 \frac{W R^3}{E I};$$

where

D = deflection of top part in inches;

W = weight of upper quadrant of frame including poles or punchings, end plates, coils and one-half the magnetic pull due to displacement;

R = radius through center of gravity of frame section in inches;

E = modulus of elasticity;

I = moment of inertia.

TABLE I.

Span, in feet.	Deflection, in inches.	Span, in feet.	Deflection, in inches.
0 to 12	$\frac{3}{64}$	16 to 20	$\frac{9}{32}$
12 to 16	$\frac{1}{16}$	20 to 24	$\frac{1}{8}$

The maximum deflection should not exceed the values given in table I.

The formulas for finding the magnetic pull, P, due to displacement of the armature are:

$$\text{For 4-pole machines, } P = \frac{B^2 A h}{36{,}067{,}000} \text{ pounds;}$$

$$\text{For 6-pole machines, } P = \frac{B^2 A h}{15{,}350{,}000} \text{ pounds;}$$

$$\text{For 8-pole machines, } P = \frac{B^2 A h}{10{,}304{,}000} \text{ pounds;}$$

$$\text{For 10-pole machines, } P = \frac{B^2 A h}{7{,}525{,}000} \text{ pounds;}$$

$$\text{For 12-pole machines and larger, } P = \frac{B^2 A h N}{72{,}134{,}000} \text{ pounds;}$$

where

A = area of pole face in square inches;

N = number of poles;

B = normal density at pole face.

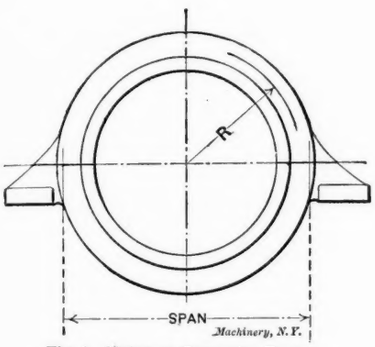

Fig. 1. Motor or Generator Frame.

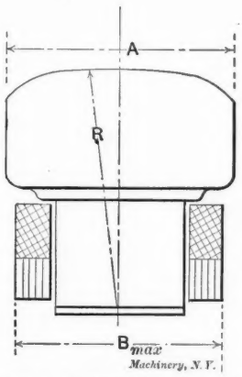

Fig. 2. Cross-section through Frame and Pole.

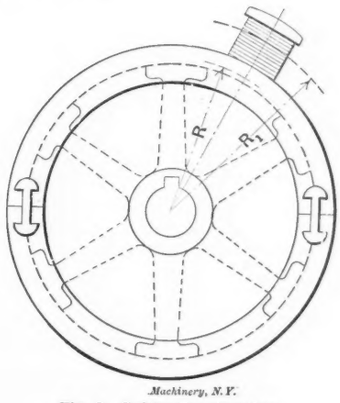

Fig. 3. Spider Construction.

If further

d = displacement of armature, in inches,

g = average normal air-gap, in inches,

a = normal reluctance of one air-gap,

b = normal reluctance of one-half the complete circuit,

$$\text{then } j = \frac{b}{a} = \frac{\text{amp. turns for one-half the circuit}}{\text{ampere turns for one air gap}};$$

$$\text{and } h = \frac{d\,a}{g\,b} = \frac{d}{j\,g};$$

Fig. 2 shows a section through the frame and pole. The width should be taken so as to extend outside the field coil on both sides.

$A = B_{\max.} + 1\frac{1}{2}$ inch,

$R = 2A$, in which formulas

A = width of frame, in inches;

$B_{\max.}$ = maximum width of field coil, in inches;

R = radius for the curvature of frame, in inches.

Spider.—The rotating part generally consists of a spider supporting the armature punchings or rotating field poles. The bore of the hub is dependent on the shaft diameter which will be considered later. The outside diameter of the hub, Fig. 4 can be taken as approximately twice the bore.

$$D = 2d.$$

The arm section can be made in many different ways. Fig. 5 shows some sections very frequently used in modern machines.

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It is often desirable to know the stress in the arms, and for that purpose the following method may be used:

If

L = length of one arm in feet, measured from center line of shaft;

A = number of arms;

$H.P.$ = horsepower of dynamo;

N = revolutions per minute;

K = bending on each arm, in pounds;

then

$$K = 5250 \frac{H.P.}{A\,N\,L}$$

If l = length of arm measured from outside of hub;

M_r = moment of resistance for arm section;

f = fiber stress in arm;

then

$$f = \frac{K\,l}{M_r}$$

For cast iron f should not exceed 4,000 to 6,000 pounds per square inch.

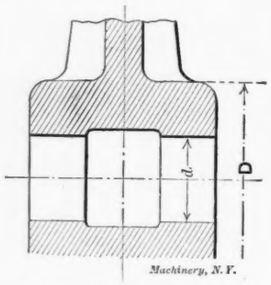


Fig. 4. Section through Hub.

Pole Ring.—In the rotating field type of alternators the poles are bolted, or fastened in any other way, to a cast-iron or cast-steel ring (Fig. 3) supported by the spider. The fiber stress can easily be figured.

If W = weight of ring in pounds,

W_1 = weight of all poles and coils;

F = centrifugal force of ring;

F_1 = centrifugal force of poles and coils;

R = mean radius of ring, in feet;

R_1 = mean radius of poles, in feet;

N = revolutions per minute;

then $F = 0.000341\ W\ R\ N^2$

and $F_1 = 0.000341\ W_1\ R_1\ N^2$.

The resultant of half the radial forces taken at right angles to the diameter is $\frac{2}{\pi}$ of the sum of these forces.

If S = total strain in ring;

A = cross-section of ring, in square inches;

then

$$S = \frac{F + F_1}{2\,\pi}, \text{ and}$$

$$\text{Fiber stress in the ring} = \frac{S}{A} \text{ pounds per square inch.}$$

It very often happens that the pole ring cannot be cast in one piece. Then some method for fastening the two halves together must be found. One very frequently used is that with links, as shown in Fig. 6.

These links are driven in a groove in the ring when hot and will then, when cold, contract and thus make a good and strong joint.

L_1 = length of groove;

L = cold length of link;

$$L_1 > L$$

The size of the link is figured to withstand the centrifugal force of the two ring-halves and should be a fiber stress in a

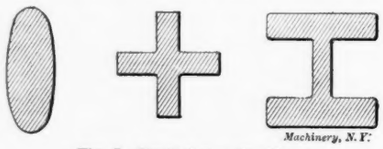


Fig. 5. Typical Arm Sections.

wrought-iron key of about 8,000 to 10,000 pounds per square inch. If the key be held to prevent its expansion or contraction the stress, f, produced by change of temperature is:

$$f = c\ t\ E;$$

where t = temperature change in degrees F.:

E = modulus of elasticity;

c = expansion coefficient per degree F. per unit length;

$c = 0.0000067$ for wrought iron;

$c = 0.0000065$ for steel.

Example.—What would the exact cold length, L, of a wrought iron link be, that the stress, f, when it is in place and cold should be 20,000 pounds?

Length of slot, $L_1 = 9$ inches

$E = 29{,}000{,}000$ to $30{,}000{,}000$

$$f = c\,t\,E; \text{ hence } t = \frac{f}{c\,E}$$

$$t = \frac{20{,}000}{0.0000067 \times 30{,}000{,}000} = 100 \text{ degrees F.}$$

$$L_1 - L = 9 \times 0.0000067 \times 100 = 0.006 \text{ inch}$$

$$L = 9 - 0.006 = 8.994 \text{ inches}$$

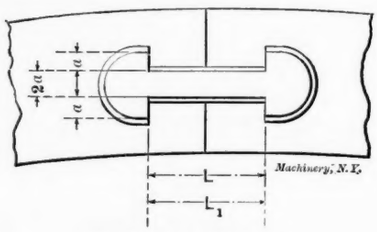


Fig. 6. Link Connection.

To find the stress in the bolts holding the poles in place on the ring, find the centrifugal force for one pole and coil, and divide this by the cross section of a bolt times the number of bolts per pole.

Shaft.—For large engine-driven generators where a heavy flywheel is used, the size of shaft is mostly fixed by the engine builder. With belt-driven machines the shaft and bearings are as a rule furnished by the dynamo builder. To properly dimension these, it is often necessary to figure the stress and deflection in the shaft and the bearing pressure. Fig. 7 shows a belted dynamo, and the following formulas will illustrate the method of figuring:

P = pounds pull at surface of pulley or pinion;

$$P = \frac{H.P. \times 33{,}000}{\text{belt speed}}$$

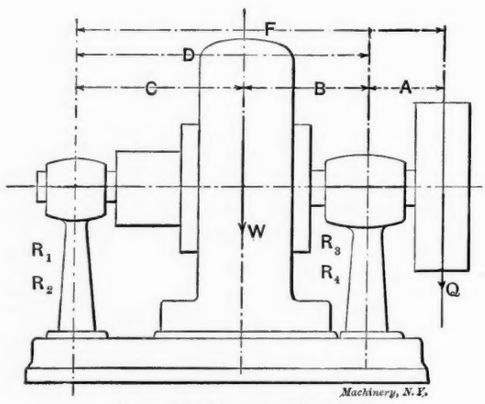


Fig. 7. Shaft Stresses Illustrated.

For belted generators $Q = 3P$ + weight of pulley or pinion;

For direct-driven generators $Q = P$;

W = weight of armature and commutator + magnetic pull due to 1/32 inch displacement.

R_1 and R_3 = load on bearing when W and Q act down.

R_2 and R_4 = load on bearing when W acts down and Q upward.

$$\pm R_1 = \frac{W\,B - Q\,A}{D}$$

$$R_2 = \frac{W\,B + Q\,A}{D}$$

$$R_3 = \frac{W\,C + Q\,F}{D}$$

$$\pm R_4 = \frac{W\,C - Q\,F}{D}$$

M_b = bending moment;
M_t = twisting moment;
M_c = combined bending and twisting moment;
M_r = moment of resistance.
M_b at $R_3 = Q\,A$; M_b at $W = R_2\,C$;
M_t = $P \times$ radius of pulley.

$$M_t = \frac{H.P.}{N} \times 63{,}024; \quad M_t = \frac{K.W.}{N} \times 84{,}450;$$

$H.P.$ = horsepower;
N = revolutions per minute.
$M_c = 0.975\,M_b + 0.25\,M_t$ when M_b is greater than M_t;
$M_c = 0.6\,M_b + 0.6\,M_t$ when M_b is less than M_t;

$$M_c = M_r = \frac{1}{10} f\,D^3$$

f = fiber stress in shaft = 7000 to 8000 pounds per square inch.
D = diameter of shaft in inches.

then

$$D = \sqrt[3]{\frac{M_c \times 10}{f}}$$

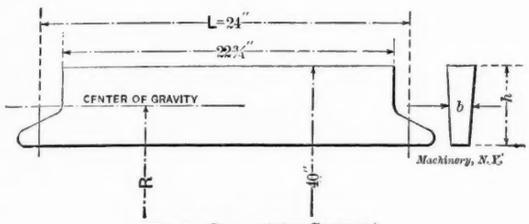


Fig. 8. Commutator Segment.

The deflection, d, of the shaft, neglecting Q, is:

$$d = \frac{W\,C\,B\,(2\,D - C)}{27\,E\,I\,D} \sqrt{3\,C\,(2\,D - C)};$$

E = modulus of elasticity = 29,000,000 to 30,000,000;
I = moment of inertia = $0.0491 D^4$.

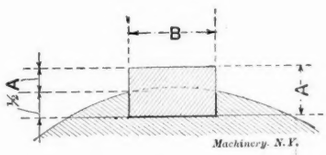
Table II. shows the allowance to be made on the shaft to secure a good press fit of the spider hub.

TABLE II.

Diam. of Shaft.	Allowance.	Diam. of Shaft.	Allowance.
⅝" to 1¾"	+ 0.0005"	12" to 13¾"	+ 0.0035"
2" to 3⅜"	+ 0.001"	14" to 17½"	+ 0.004"
4" to 5⅞"	+ 0.0015"	18" to 20¾"	+ 0.0045"
6" to 7¾"	+ 0.002"	21" to 24½"	+ 0.005"
8" to 9⅝"	+ 0·0025"	25" to 27½"	+ 0.0055"
10" to 11¼"	+ 0.003 "	28" to 31¾"	+ 0.006"

Table III. gives the sizes for keys to use in mounting the spider on the shaft.

TABLE III.



Diam of Shaft.	A	B	Diam. of Shaft.	A	B
⅝"– 15/16"	3/16"	3/16"	5½"– 7"	1"	1½"
1" –1 3/16"	¼"	¼"	7¼"– 8½"	1¼"	1⅝"
1 7/16"–1 11/16"	¼"	⅜"	8⅝"–10"	1⅜"	2"
1 15/16"–2 3/16"	⅜"	⅜"	10⅛"–12⅓"	1⅝"	2⅛"
2 7/16"–2 11/16"	⅜"	½"	12⅝"–15"	2"	3"
2 15/16"–3 3/16"	½"	⅝"	15⅛"–18"	2⅛"	3⅛"
3 7/16" 4 3/16"	⅝"	1"	18⅛"–23"	3" / 4"	2" / 2"
4 ½"–5 ⅝"	⅞"	1¼"	23⅛"–29"	3⅛" / 4¼"	2⅛" / 2½"

Bearings.—The diameter of the journals depends to a certain extent on the size of the shaft in the spider hub. If the diameter of the bearing is settled, then the length should be taken so that the pressure on the journal does not exceed a certain value.

If P = pressure per square inch of projected area of journal,
V = velocity of journal in feet per minute,
then the following values should not be exceeded:

P = 60 — 100 pounds normal.
P = 150 — 200 pounds maximum.
PV = 60,000 — 80,000 normal.
PV = 100,000 — 120,000 maximum.

Table IV. gives the allowances to be made in the bore of the journal boxes to secure a good running fit.

TABLE IV.

Journal Diam.	Journal Box Bore.	Journal Diam.	Journal Box Bore.	Journal Diam.	Journal Box Bore.
½"	0.501"	2"	2.004"	5"	5.009"
5/8"	0.626"	2¼"	2.2545"	5⅛"	5.5095"
¾"	0.7515"	2⅛"	2.505"	6"	6.010"
⅞"	0.877"	2¾"	2.7555"	7"	7.011"
1"	1.002"	3"	3.006"	8"	8.012"
1¼"	1.2525"	3⅛"	3.5065"	9"	9.013"
1⅛"	1.503"	4"	4.0075"	10"	10.014"
1¾"	1.7535"	4½"	4.508"	12"	12.016"

Commutator.—The commutator bars are made of hard-drawn copper and insulated from each other with mica of about 0.035 inch thickness. The bars are either upper- or undercut and clamped between two end rings. For long bars and high speed the stress in the bar often becomes very high, and the bars show a tendency to deflect. An example will illustrate the method of figuring the stress and deflection of commutator bars. Assume an uppercut bar of dimensions as shown in Fig. 8.

b = 0.75 inch,
h = 2 inches,
R = 19 inches = 1.58 feet,
N = 400 revolutions per minute.
Weight of bar, $W = 2 \times 22.75 \times 0.75 \times 0.32 = 10.9$ pounds,

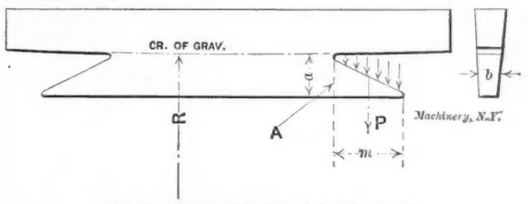


Fig. 9. Undercut Commutator Segment.

Centrifugal force, $C = 0.000341 \times W R N^2$.
$C = 0.000341 \times 10.9 \times 1.58 \times 400^2 = 945$ pounds.

$$\text{Fiber stress, } f = \frac{6\,W\,L}{8\,b\,h^2}$$

$$f = \frac{6 \times 945 \times 24}{8 \times 0.75 \times 4} = 5690 \text{ pounds per square inch.}$$

$$\text{Deflection, } D = \frac{12\,W\,L^3}{76.8\,E\,b\,h^3}$$

$$D = \frac{945 \times 24^3 \times 12}{76.8 \times 16{,}000{,}000 \times 0.75 \times 8} = 0.021 \text{ inch.}$$

f should not exceed 7,000 to 8,000 and
D not exceed 0.025 inch to 0.03 inch.
Assuming the same bar worn down ¼ inch,
Then $R = 1.56$ feet.
$W = 1.75 \times 22.75 \times 0.75 \times 0.32 = 9.5$ pounds.
$C = 0.000341 \times 9.5 \times 1.56 \times 400^2 = 810$ pounds.

$$f = \frac{810 \times 24 \times 6}{0.75 \times 1.75^2 \times 8} = 6350 \text{ pounds per square inch.}$$

$$D = \frac{810 \times 24^3 \times 12}{76.8 \times 16{,}000{,}000 \times 0.75 \times 1.75^3} = 0.027 \text{ inch.}$$

Fig. 9 shows an undercut commutator bar. As this construction necessitates a greater depth of bar, the deflection usually does not need to be figured. The greatest strain is in the section at A.

Weight of bar in pounds = W.

Centrifugal force $C = 0.000341 WRN^2$.

N = revolutions per minute.

$$P = \frac{C}{2}$$

M_r = moment of resistance of section at $A = \frac{b a^2}{6}$

f = fiber stress in section at A.

$$f = \frac{P m}{2 M_r} \text{ pounds per square inch.}$$

The calculations here given are the ones most used in dynamo construction. Some of them are only approximate but have proven to give a good and safe result. There are of course a number of other calculations that can be made, but a good judgment of the designer will reduce these to a minimum.

* * *

THE EYE AND THE MIND.*

"The effect of the practical school training upon an engineer is well shown in the following instance: The engineer referred to sent a drawing of an intricate forging to a firm in one of the Southern States. The manager sent it back, saying, 'The piece cannot be made.' The engineer, thinking that the other had misunderstood the drawing, made a wooden model of the exact shape he wished the finished piece to have. This he carried over to the works in person. The manager said, 'Not only are we unable to make this piece, but the man does not live who can make it.' The engineer said, 'May I have the use of a forge?' This was granted, and all the expert blacksmiths of the place gathered around him to see this greenhorn of an amateur make a fool of himself. He worked through his task logically step by step, and brought out the finished piece just like the wooden model. He was then asked by the manager, 'Did you ever see one made?' 'No.' 'Did you ever see one like it?' 'No.' 'How did you know one could be made, and where were you taught to make it?' 'I was taught the principles on which everything is made at the Massachusetts Institute of Technology in Boston.' At this reply the manager said, 'I don't believe a word of it.'

"The above is a very good illustration of the different ways in which the two classes of minds look at things. The trained scientific mind is ready to undertake anything. The rule of thumb man will go as far as he sees, but his imagination fails him. The former can mentally analyze and reconstruct, while the latter can do only what he has been taught.

"The use of the shop for the development of skill and imagination is well illustrated in this way: The teacher of forging shows the pupil in successive lessons how to draw a piece of iron, how to make a piece round or square, how to punch an eye, how to make a weld, how to make an offset and a rivet. He then asks his pupil to make a pair of blacksmith's tongs. The answer comes: 'But I can't. I never did such a thing in my life.' The teacher is inexorable, and the pupil begins. He finds to his surprise that the task before him is simply a grouping together of a series of steps, each of which he has already mastered. The first tongs a good student makes will compare well with the work of an average country blacksmith who has had years of experience."

* * *

A practice which has become common in the operation of the Pennsylvania coal mines is to return dust and culm to the worked-out chambers, instead of depositing the refuse in huge dumps to become an eye-sore, a constant menace from fire, and a nuisance generally. It is not generally known, however, that this practice is the result of a law which was passed to prevent the contamination of the streams and rivers by dumping the culm and dust into them, as was the former practice. The benefits of the new practice are at least twofold: the refuse is no longer a trouble to any one, and being restored to the worked-out chambers it prevents, to a large degree, the settling and surface changes that are the inevitable result of worked-out mines after the timbers begin to rot away.

* Extract from "The Relation Between Technical Education and Industrial Progress," by Robert H. Richards, in Technology Quarterly for June, 1906.

THE DESIGN OF BEARINGS.—2.

OIL GROOVING.

FORREST E. CARDULLO.

The mechanical arrangement of the box and journal may tend either to preserve or destroy the lubricating film. Both should be perfectly round and smooth, the box a trifle larger in diameter than the journal. The allowance commonly made for the "running fit" of the box and shaft, is about 0.0005 $(D + 1)$ inches, where D is the nominal diameter of the shaft in inches. Some manufacturers of fast running machinery

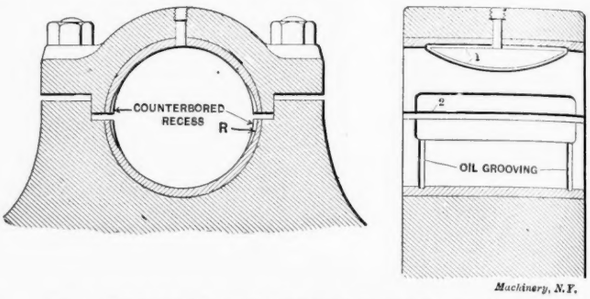


Fig. 1. Section of Outboard Bearing, showing Oil Grooving and Counterbored Recess.

make the diameter of the box exceed that of the shaft by nearly twice this amount. The oil should be introduced at that point where the forces acting tend to separate the shaft and box. At this point grooves must be cut in the surface of the box, so as to distribute the lubricant evenly over the entire length of the journal. Having been so introduced and distributed, the oil will adhere to the journal, and be carried around by it as it revolves to the point where it is pressed

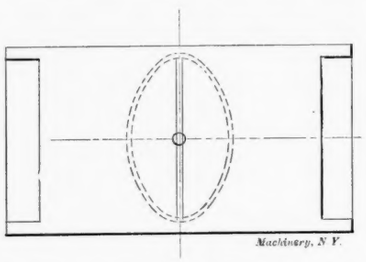


Fig. 2. Development of Cap showing Oil Grooving and Counterboring.

against the box with the greatest force, thus forming the lubricating film which separates the rubbing surfaces. The supply of lubricant thus continually furnished, and swept up to the spot where it is needed, must not be diverted from its course in any way. A sharp edge at the division point of the box will wipe it off the journal as fast as it is distributed, or a wrongly placed oil groove will drain it out before it has entirely accomplished its purpose.

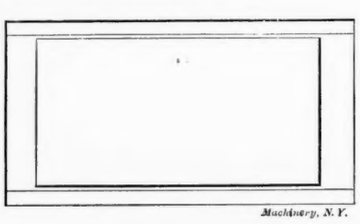


Fig. 3. Development of Lower Half of Outboard Bearing.

An important matter in the design of bearings is the cutting of these oil grooves. They are a necessary evil, and should be treated as such, by using as few of them as possible. They serve, first, to distribute the lubricant uniformly over the surface of the journal, and second, to collect the oil which would otherwise run out at the ends of the bearing, and return it to some point where it may again be of use. As generally cut, oil grooves have two faults; first, they are so numerous as to cut down to a serious extent the area of the

bearing, and second, they are so located as to allow the oil to drain out of the bearing. Let us take an ordinary two-part cap bearing such as the outboard bearing of a Corliss engine, and see how it is best to cut the grooves.

One of these bearings, as commonly made by good builders, is shown in Fig. 1. The oil is supplied, drop by drop, through a hole in the cap. If there were no oil grooves, only a narrow band of the shaft revolving immediately under this hole would be reached by the oil. If, now, we cut a shallow groove in the cap, lengthwise of the bearing, and reaching almost, but not quite, to the edges, the oil will be enabled to reach every part of the revolving surface. To this groove we sometimes

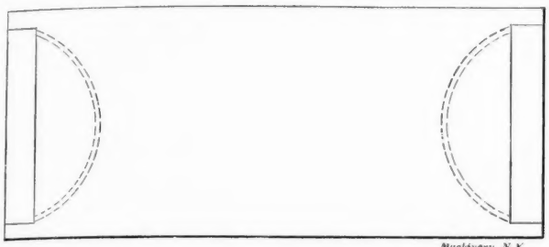


Fig. 4. Face of Crosshead Slipper.

add two, as shown by the dotted lines in Fig. 2, which shows the inner surface of the cap as being unrolled, and lying flat on the paper. No series of grooves can be cut in the box which will distribute the oil as well or as thoroughly as those shown, and they should always be used in the caps of such bearings in preference to any others.

Having distributed the oil over the revolving surface, our next care must be to see that it is not wiped off before it reaches the point for which it was intended. Accordingly, we should counterbore the box at the joint in such a way as to make a recess in which the surplus oil may gather, and which will further assist when necessary in distributing the lubricant. This counterbore should extend to within ¼ or ½ inch of the ends of the bearing, as shown in Fig. 1.

When the oil is supplied through the cap, grooves for the distribution of the oil should not be cut in the bottom half of the bearing, since they will only serve to drain the bearing of the film of oil formed there. The oil film is under

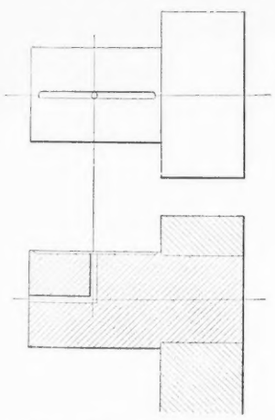


Fig. 5. Internally-oiled Crankpin, showing Oil Passages and Grooves.

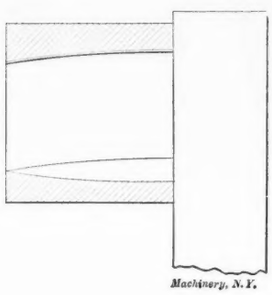


Fig. 6. Section showing the Bending of a Crankpin and Consequent Unequal Wear of the Box.

great pressure at this point, and naturally tends to flow away when any opportunity is offered. If left to its own devices, part of it will squeeze out at the ends of the bearing and be lost. In order to save this oil, shallow grooves, parallel to the ends of the bearing may be cut in the lower box, as shown in Figs. 1 and 3. Their office is to intercept the oil which would flow out at the ends, and divert it to the counterbored recesses, where it can again be made of use. These are the only grooves that should ever be used in the lower half of a two-part bearing, and they should only be used in the larger sizes.

Two classes of bearings which may well be made without oil grooves are, first, the crosshead slippers of engines, and second, crankpin boxes. The crosshead slipper should have a recess cut at each end, in the same way as the counterboring of the two-part box, as shown in Fig. 4. To this is sometimes added the semi-circular groove shown in dotted lines, which does no harm, although it is unnecessary. The best way to oil a crankpin is through the pin itself. In the case of overhung pins, a hole is drilled lengthwise of the pin to its center. A second hole is drilled from the surface of the pin to meet the first one. A shallow groove should now be cut in the surface of the pin, parallel to its axis, and reaching almost to the ends of the bearing, as shown in Fig. 5. No grooves should be cut in the boxes, but the edges where they come together should be counterbored.

As much care and attention should be given to the oil grooving as to the size of a bearing, yet it is a matter often left to the fancy of the mechanic who fits it. The purpose of the grooves, to distribute the oil evenly, should ever be kept in mind, and no groove should be cut which does not accomplish this purpose, except it be to return waste oil to where it may again be of use. Most bearings that I have seen have too many grooves. So far from helping the lubrication, they generally drain the oil from where it is most needed. Use them *sparingly*.

* * *

OLD AND HEAVY MACHINE TOOLS IN BOSTON NAVY YARD.

H. P. FAIRFIELD.

The cuts accompanying this article are of machines that interest me from several points of view. The first is that of their age. To any one interested in the mechanical progress of our country, even medium age in a machine has its lesson. The second point of interest is their size, and they are certainly large, even in this day of large machines. Then again,

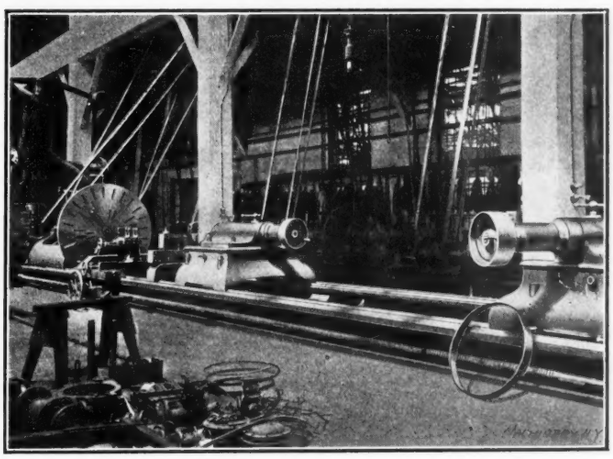


Fig. 1. Lathe with Head, Cross-slide and Tailstock at each End. Designed by Seth Wilmarth. Built at Boston Navy Yard, 1866. Swing, 6 feet 8 inches; Bed, 60 feet long.

some of them are interesting to New England machinists and designers as representing the state of the art as developed by two or three firms which at that time undoubtedly led the world in good machine practice and design. A prominent machine designer and builder recently made the remark that in many respects, notably the distribution of material and completeness of mechanisms, they would compare most favorably with like machines of to-day. I am told that these machines were built and set up at the close of the Civil War in preparation for the expected increase in powers in marine work, particularly as relates to war vessels. While the growth occurred, as prophesied, it was not along the lines prepared for. Instead of a cylinder of enormous bore and great length of stroke, the development of energy was divided among several cylinders, relatively smaller in size and the engine frame work was and is built along like lines. While the engine as a whole is enormously powerful and massive, the individual parts are each of a size that renders it possible for them to be made or repaired in machine tools not excessively large. These machines have therefore never been in so active a use as it was expected that they would be. They are thus, to a great extent, obsolete and must eventually make way for other ma-

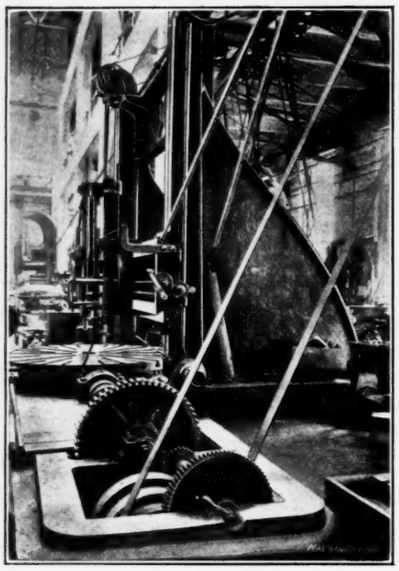


Fig 2. Boring Mill. Built by Bement & Dougherty Industrial Works, Philadelphia, Pa. Will swing 12 feet across and 9 feet 6 inches high. Provided with Drilling Head.

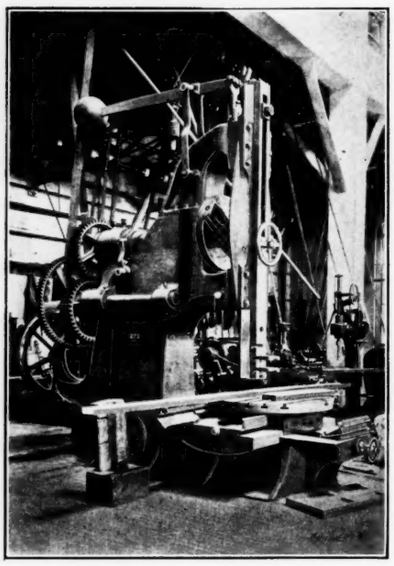


Fig. 3. Slotter. New York Steam Engine Company, Builders, N. Y., 1868. Works at Worcester, Mass.

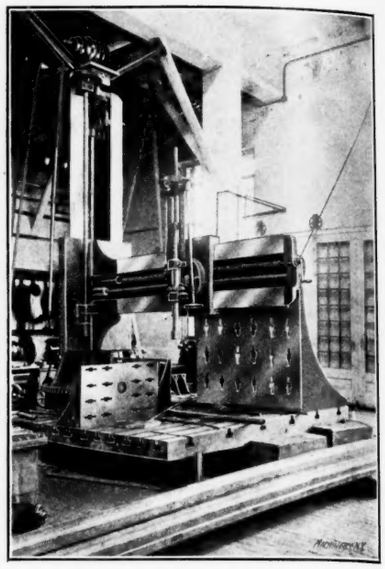


Fig. 4. Radial Drill. Built in 1868 by Lowell Machine Company. Distance, Center of Spindle to Column, 12 feet 4 inches. Will Operate on Work 10 feet high.

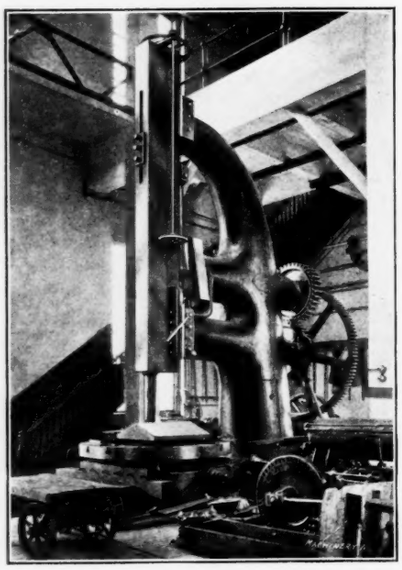


Fig. 5. Slotter. Boston Machine Co., Designers and Builders, Boston, Mass., 1868. Thirty-six-inch stroke; Cross-feed, 42 inches; Longitudinal Feed, 72 inches. Also has Rotating Feed. Admits Work 48 inches high.

chinery, not on account of their design so much as their over-size for the required use.

To illustrate the quality of the workmanship in these old shops an incident that occurred when Mr. Whitworth made his visit to this country may be related. During his call at the old Boston Machine Co.'s office, he exhibited two small blocks which, when carefully cleaned and twisted together to force out the air, would lift one another. In the shops of the Boston Machine Co. were two large surface plates used to test scraped work upon and the superintendent knew these to be about right. He therefore asked his visitor into the shop, and by means of a crane placed one of the large plates upon the other. After the top plate had been worked around to expel the film of air, hoisting upon the upper brought both as one piece, and as the Westerners say, "called the bluff." While it was to be expected that the result would be just as it proved it did rather discount the pretty pieces wrapped in tissue. Pure manual skill probably

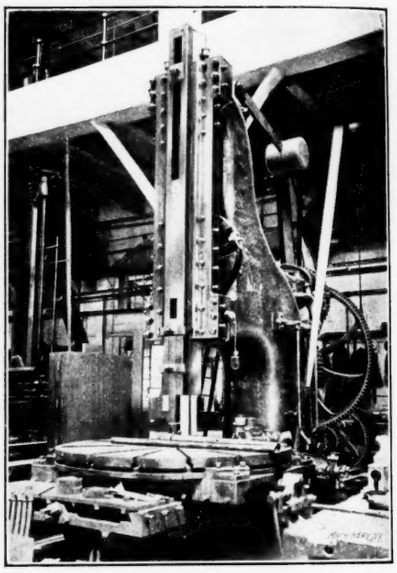


Fig. 6. Slotter. Built by John Roach & Son, Morgan Iron Works, New York City.

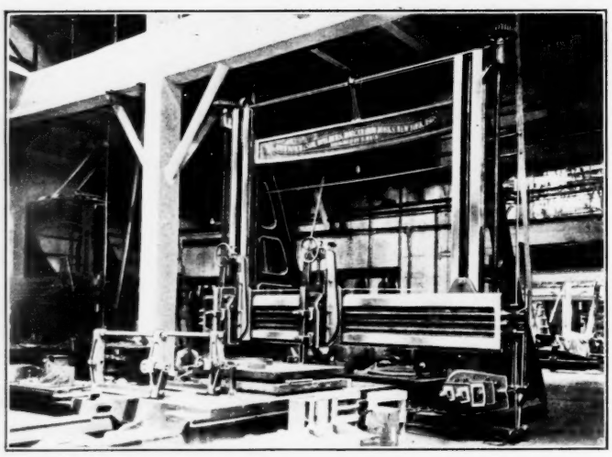


Fig. 7. Planer. John Roach & Son, Morgan Iron Works, N. Y., 1868. Designed by T. Main. Twelve feet 1 inch between Housings. Bed, 7 feet wide, 25 inches long. Will admit 12 feet under the Rail.

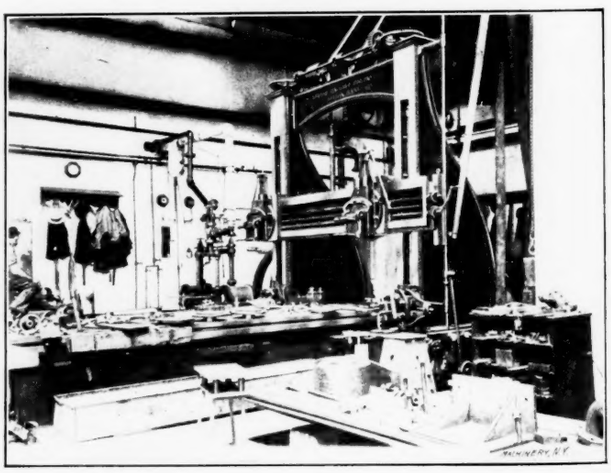


Fig 8. Planer. Built by Boston Machine Company, Boston, Mass., 1867. Eight feet 1 inch between Housings. Bed, 5 feet wide, 19 feet long. Will take 8 feet 4 inches under Rail.

reached its highest tide in both the machine shop and drafting room at about the sixties.

These machines have for the most part remained idle for years, and are now being broken up whenever the room they occupy is needed. I trust that the publication of the photographs will bring out the history of the several firms that built the machines illustrated and lead to others being shown.

* * *

CENTRIFUGAL PUMPS.*

Obviously the best way to consider centrifugal pumps is to compare them with their competitors, reciprocating pumps. In the centrifugal pumps we have no shock or water hammer because the liquid is always in motion and the flow is unceasing, no air chamber being required to provide smooth operation. In the first place the efficiency of the centrifugal pump is very nearly equal to that of the reciprocating type, and especially so when the centrifugal type is direct connected to either an engine or a motor. Durability of the centrifugal pump is another feature; if we consider an equal expenditure of repairs being made on each machine, for ten years of service, the efficiency of the reciprocating pump would be very low, whereas the efficiency of a centrifugal pump would be maintained because the only wearing parts are the bearings, which are lubricated with oil-rings and require very infrequent replacement. Compare this with the wearing out of the water cylinder linings of the reciprocating pump. The centrifugal pump can handle gritty or acid liquids, and as it has no valves it can also handle water containing pulp or slime. The speed of the centrifugal pump is so high that it may be direct-connected to a motor or engine, whereas, the reciprocating pump must be geared either through one or two speed combinations, with the attendant loss of power and resulting noise. Due to its higher speed the centrifugal pump also occupies less space for a given capacity, and particularly in mine work this is an important feature.

Centrifugal pumps may be divided into two distinct types, namely, the volute type and the turbine type. While the volute type is more practical for lower heads, and where maximum efficiency is not absolutely necessary, the second, or turbine type, is used where high heads and maximum efficiency are required. In general, we may say that the turbine pump will require about ten per cent less horsepower for a given head and water quantity than the volute pump under the same conditions, and while either type of pump may be built to compound two or more stages, it is almost universal practice to use only the turbine type for compound units, for aside from a somewhat higher efficiency result, it lends itself more readily to a compact, mechanical arrangement. All types of centrifugal pumps consist of two essential elements, first, the rotating impeller which receives the water entering at the inlet, and second, a stationary water way contained in the outer shell, which receives the water thrown from the end of the impeller. In the design of these two elements rests the secret of the success of the pump and the percentage of efficiency obtained. If the water were received from the inlet directly into the impeller without its course being changed by following a curve of the proper proportions, a large loss of power would result; secondly, if the water were discharged from the impeller directly into a large chamber, the efficiency of the pump would be very low, as the kinetic energy, or velocity of the water, would be entirely lost. The greater portion of this kinetic energy, or velocity, is used by directing the water into a throat and volute, or a diffusion ring. The throat, or diffusion ring, is merely an expanding water way which allows the velocity of the water to be decreased gradually. The proper proportion of the throat and the correct curve for the vanes in the diffusion rings are the result of many tests covering several years. It may be stated without exception that the general form of the volute, or passage way in which the water finally finds its way to the outlet of the pump, is that of an Archimedes spiral, that is, the cross-section increases in an arithmetic ratio up to the full area of the pump discharge.

To further draw a comparison between reciprocating direct-acting and centrifugal pumps, we may note the three chief variables, *viz.*, head, volume, and speed. Given any constant head, the volume and speed are proportional, though not a simple function. A direct-acting pump, however, has a capacity or volume directly proportional to the number of revolutions. For any constant volume the speed required to operate the pump is a function of the square root of the head, while if we consider the speed constant, and note the effect of changing volume and speed, we shall find that their relations, though similar to that occurring with constant head, differ in that a greater change takes place in the volume for a change of head, and also that the variations are in the opposite direction. This will be readily appreciated when it is remembered that the water horsepower must be approximately constant.

If u_2 = the peripheral speed of runner in feet per second,
H = the head,
V = the velocity in feet of the water in the discharge pipe,

then $u_2 = \sqrt{b\,H + a\,V^2} + a\,V$, where a and b are constants.

$H = 0.031\,K \times (u_2{}^2 - u_2 \times V \times \cot \alpha$.

in which K is a constant and α the angle of the blade at the circumference of the impeller.

H = head.

If the water be gritty or contains solid matter of any nature, we cannot select the usual speed, owing to the excessive wear which would result if the pump were running at as high a speed as with clear water. This is one of the most important considerations—limiting the speed of the pump—and is the factor which governs the capacity of dredging pumps. One way of providing for a lower rotative speed is to build the pump in two or more stages—thus dividing the R. P. M. by 2, 3, 4, etc. Though up to this time no pumps in this country have been constructed containing more than eight stages it seems entirely feasible to build them with more.

* * *

The Schenectady plant of the American Locomotive Co. completed the company's 40,000th locomotive in November, 1906. This number includes the total output of the ten constituent companies owned and controlled by the American Locomotive Co., namely: Schenectady Locomotive Works, Schenectady, N. Y.; Brooks Locomotive Works, Dunkirk, N. Y.; Pittsburg Locomotive Works, Pittsburg, Pa.; Rhode Island Locomotive Works, Providence, R. I.; Richmond Locomotive Works, Richmond, Va.; Rogers Locomotive Works, Paterson, N. J.; Dickson Locomotive Works, Scranton, Pa.; Locomotive & Machine Co., Montreal, Canada; Cooke Locomotive Works, Paterson, N. J.; Manchester Locomotive Works, Manchester, N. H. The oldest company represented is the Rogers Locomotive Works, founded in 1831. The first locomotive built by Rogers was the *Sandusky*, for the Mad River & Lake Erie R. R. Co. in 1837. The 40,000th locomotive is one of two Cole balanced compounds, built for the Northern Pacific R. R. They are of heavy design, the weight in working order being 240,000 pounds; on the drivers 157,000 pounds; and the total weight of engine and tender, 380,500 pounds. Both locomotives of the order are equipped with the Walschaerts valve gear.

* * *

In the article on the new Engineering Building of the University of Pennsylvania which appeared in the engineering section of the December issue, mention was made of the forge shop equipment including a 250-pound steam hammer. It should have been mentioned that this hammer was furnished at cost to the University by the Erie Foundry Co., Erie, Pa.

* * *

A correspondent of *Power* publishes the following amusing letter, received from one in Montana, who had been solicited to buy a kerosene engine and electric generator outfit: "Messrs.: Your power may do when we get that cheap, good-natured alcohol. Not now with kerosene at 30 cents per gallon."

* This article, contributed by the Buffalo Steam Pump Co., Buffalo, N. Y., may be supplemented with tables of capacities of their centrifugal pumps giving the cubic feet, gallons, revolutions per minute and other data for heads varying from 5 to 100 feet which will be found in a free booklet issued by the company. These tables cover velocities in the discharge pipe of from 12 to 15 feet per second.

FRICTION COUPLINGS FOR HOISTING MACHINERY.

C. F. BLAKE.

In the operation of power cranes it is important that certain motions may be placed in gear without stopping the motor. This is accomplished by friction clutches, in which one portion is keyed to the shaft, while the other is connected to the member to be driven. Arrangement is made to thrust the two portions of the clutch together, and lock them in powerful frictional engagement. The friction coupling is the reverse of the friction brake in general principles, and many such couplings are made on the principle of the Weston brake.

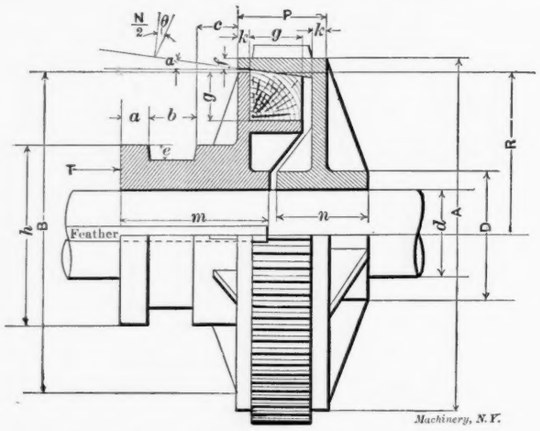


Fig. 1. Diagram Illustrating Construction and Theory of Cone Friction Coupling.

There are numerous patented friction couplings on the market more or less adapted to crane work, according to the demands of the designer. In selecting a coupling it is well to make provision for placing a band brake on the shell of the loose part connected to the member to be driven, as this often becomes a great convenience. The design of the Weston coupling may be readily accomplished by reference to the formulas for the Weston brake in the October, 1906, issue.

The cone coupling will be understood by reference to Fig. 1. The left-hand portion carrying the wood friction is keyed to the shaft by a feather, while the right-hand portion carrying the gear is loose on the shaft, and must be bushed and backed against a collar to resist the end-thrust when engaging the coupling.

Let M = the torsional moment in inch-pounds transmitted through the coupling,

N = the total normal pressure between the conical surfaces,

P = the tangential force at radius R,

T = the engaging pressure on the loose portion,

$\mu = \tan \theta$ = coefficient of friction.

If it is desired to set the clutch with the machinery at rest we have the following formulas*:

$$N = T \operatorname{cosec} (\alpha + \theta) = \frac{T}{\sin (\alpha + \theta)}$$

$$P = \mu N = \frac{\mu T}{\sin (\alpha + \theta)}$$

$$M = PR = \frac{\mu T R}{\sin (\alpha + \theta)}$$

Since it is the purpose of the friction clutch to engage while the machinery is in motion, it is usually unnecessary to set the clutch while at rest, and therefore the statical friction need not be considered, and the formulas become:

$$N = \frac{T}{\sin \alpha} \qquad P = \frac{\mu T}{\sin \alpha}$$

$$M = \frac{\mu T R}{\sin \alpha}$$

As to the angle γ authorities differ, making it all the way from two to ten degrees. Reuleaux makes it ten degrees. For the remainder of the dimensions the following values may be used:

$A = 4d$ to $8d$.	$e = 0.3d + 0.1$ inch.
$f = 0.2d + 0.1$ inch.	$k = 0.2d + 0.3$ inch.
$B = A - (2f + 0.257$ inch).	$g = 0.8d$ to $2d$.
$h = 2d + 1$ inch.	$D = 1.8d + 0.5$ inch.
$c = 0.5d$.	$F = 2d$.
$a = 0.3d + 0.3$ inch.	$m = 2d$.
$b = 0.4d + 0.4$ inch.	$n = d$ to $1.5d$.

A form of this clutch frequently seen is shown in Fig. 2. The drum D, loose on the shaft, carries the wood friction cone W which engages with the gear cone C keyed to the shaft, the two being disengaged by the spring S, and engaged by moving the drum on the shaft as follows:

The shaft box B carries a cap E in which is a screw stud A in a babbitted nut b. This stud is in contact with one end of a rod L in the shaft, the other end of which is in contact with the cross key k, movable lengthwise in the shaft. The collar C having slots to receive the cross key, is placed between the cross key and the drum hub.. A partial turn of the stud A by means of a crank or lever, will, through the rod L, move the cross key, and with it the drum, lengthwise on the shaft, thus engaging the friction cones W and C. A split collar n is placed on the end of the shaft to prevent end motion from the thrust of the shaft stud.

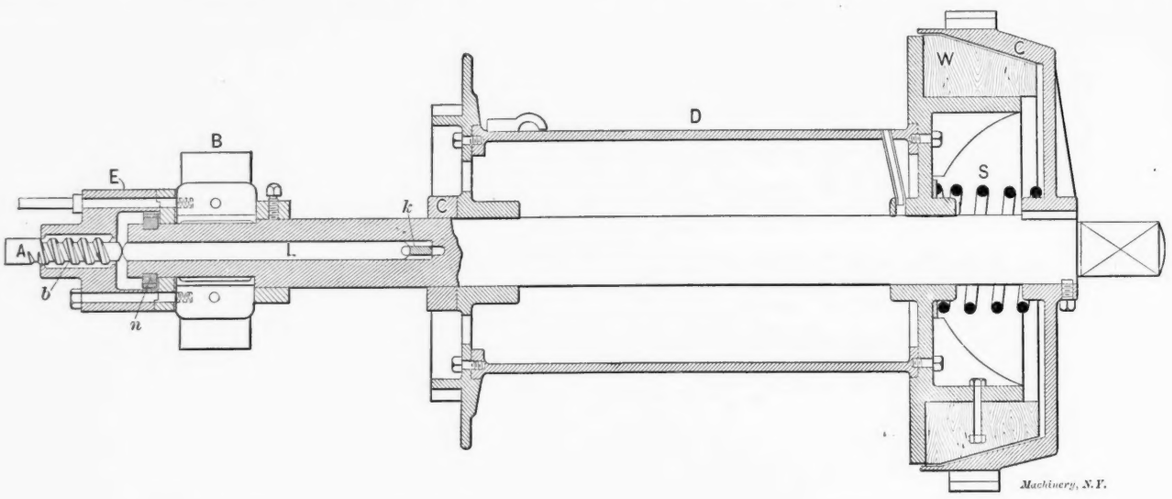


Fig. 2. Cone Friction Coupling Applied to Spool of Hoisting Machine.

*The angle of repose of the materials composing the friction surfaces represented by θ enters into the equations for coupling at rest for the obvious reason that the normal pressure exerted on the conical surface depends upon the efficiency of the wedge action of the cone. But for coupling when one part is in motion the statical friction of the clutch surfaces is not considered, as then the resistance to endwise motion of the cone becomes practically zero so far as frictional resistance to engagement is concerned. This is illustrated by the ease with which a shaft may be shifted longitudinally when running, although perhaps carrying a load of many tons.—EDITOR.

A SKEW BEVEL GEAR MODEL.

JOHN F. ARTHUR.

John F. Arthur.

In the gear model shown in Fig. 1, we have two shafts at right angles to each other in planes about 1¾ inch apart, connected at their intersection with the normal to the two planes by a pair of spiral gears, and at their outer extremities by a pair of approximate skew bevel gears. It is not possible to show the condition in the cut, but if the eye be placed at the outer end of a tooth of one of the bevel gears, it will be seen that there is a corresponding tooth of the spiral gear on the same shaft directly in line with it, and inclined at the same angle with the axis. In other words, straight teeth might be drawn from the outer edge of the bevel gear to the central spiral gear, filling all the space between them. The pitch surface on which these teeth would have to be made, though they are themselves straight, would not have a straight cross section but would be in the form of a hyperboloid. To illustrate the nature of the pitch surfaces required for a pair of skew bevel gears, I have constructed and show herewith a pair of models illustrated in Figs. 2 and 3.

To a U-frame of strap iron are fastened by clamp bolts and wing nuts the two wooden disks shown, these disks having the same axis. A groove is turned in the outer face of each disk close to the outer edge, and 20 equi-distant saw cuts are made in the periphery to a depth sufficient to just enter the grooves; this construction is best seen in Fig. 3. An endless elastic cord is interwoven in the saw cuts, being prevented from unloosening and falling out by the groove, whose lip makes a ledge to retain it in place. As shown in Fig. 3, in the normal condition the disks are so arranged that the elastic cords are all stretched parallel with the axis. A model in this condition may be considered as representing a spur gear of 20 teeth, each string representing a tooth. If two such models be placed side by side with the peripheries of the disks tangent, they may be rolled upon each other, when the strings of one may be made to coincide with the corresponding strings of the other as they revolve.

If now the left hand disk, for instance, of each model be unloosened and rotated in the same direction through a given number of degrees, the two models may again be placed in contact with each other with their axes askew by such an amount as will bring a string of one model coincident with a string of the other. With the axes fixed in these positions the two models might be revolved, when each string in turn during a complete revolution would coincide with a corresponding string on the other model. The greater the angular displacement of the adjustable disks the greater will be the angle which the axes of the two models make with each other in parallel planes. If the pitch diameters of the disks are greater than the distance between them a point will be reached, as shown in Fig. 2, when enough twist has been given each of the movable disks to bring the axes of the two models at right angles when they are put together with corresponding strings coincident. When in this condition, the outline of the surface generated by the strings as the model is rotated about its axis gives the hyperboloid or pitch surface on which it would be necessary to place teeth in the model shown in Fig. 1, if it were desired to fill up the space included between the spiral gear and the bevel gears. The shape of this surface will be understood from the left-hand view in Fig. 3, where one of the two models of Fig. 2 is shown separately.

This hyperboloidal surface may be understood by considering another method of generating it. If we take between the centers of a lathe the wooden cylinder *A B C D* as shown by the dotted lines in Fig. 4 and feed into it a knife blade *E* set at an angle as shown, this knife blade would generate a spool shaped solid having the outline indicated, and its exterior surface would be a hyperboloid. The mark which might be made by pressing with the knife into the surface of this figure when generated, the blade being in the position shown, would represent the line of contact between this solid and another one generated in the same manner, if they were put together with their curved surfaces tangent to each other. This line may also be taken as representing one of the strings in the model just described. The models and the turning lathe illustration just given demonstrate very clearly the fact that two hyperboloidal surfaces properly proportioned will touch each other on a straight line of contact.

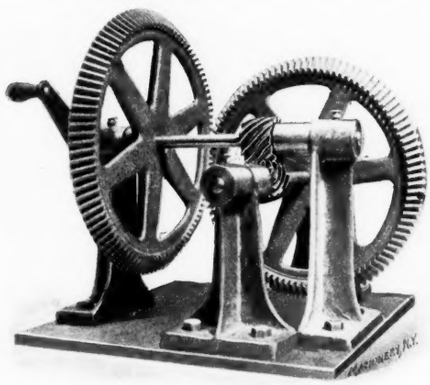


Fig. 1. Two Shafts Connected by both Spiral and Skew Bevel Gears.

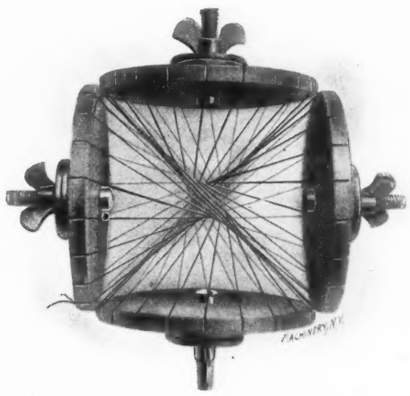


Fig. 2. Model Illustrating Two Skew Bevel Gear Pitch Surfaces in Contact.

While the set of gears shown in Fig. 1 (in combination with the string model) demonstrates the pitch surface required, it has not been given teeth which accurately fulfil the requirements of the case. The spiral gears at the center, instead of having curved pitch surfaces, have been cut with cylindrical ones which theoretically only touch at a single point in the center. With a little use, however, they wear themselves to an indescribable shape, depending on the material of which they are made, and this shape doubtless approximates the skew bevel action required. In the case of the two outer bevel gears accuracy is impossible, since the teeth slide laterally on each other, thus bringing different pitches in contact, the conditions varying constantly between the times of entering and leaving. These skew bevel gears are therefore a kind of compromise mechanism which will transmit a moderate power, but must be cut with the spaces more than half of the pitch, with the thickness of the teeth less than the standard by the same amount.

If one of the disks in the model shown at the right in

JOHN F. ARTHUR, secretary of the Arthur Co., New York was born in Glasgow, Scotland- 1870. The family came to the United States when he was eighteen months old, and settled in New York. He took up the machine business under the direction of his father, Mr. James Arthur, and went through a regular machine shop training. Mr. Arthur is a machine designer, and has taken out several patents on devices pertaining to the business of the concern, which is largely gear cutting. He has always given the subject of gear making special attention, and has constructed a number of interesting gear models, besides the above, to illustrate principles.

Fig. 3 is turned around 180 degrees, we bring all the elastic strings to a common point of intersection in the center, thus altering our skew bevel hyperboloid pitch surfaces until they become the conical pitch surfaces of bevel gears. It is of course understood that, since the elastic cord used has a sensible thickness, all of the strands cannot be brought to a common point in the case of the bevel gear. The principle illustrated, however, will readily be grasped. The skew bevel pitch

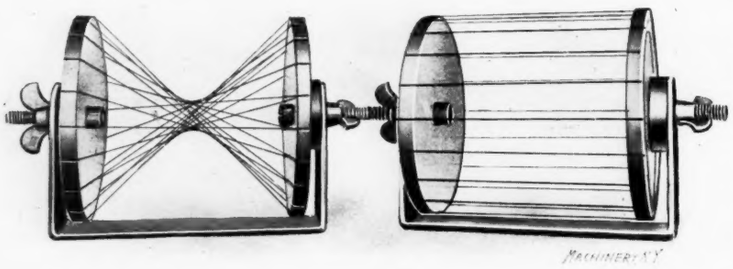


Fig. 3. Models set to show Skew Bevel Gear and Spur Gear Pitch Surfaces.

surface shown in Fig. 3 may thus be altered to the spur gear pitch surface in the same Fig. or the bevel gear pitch surface just described, all the intermediate forms being hyperboloids. The skew bevel gear is thus, in a sense, the progenitor of all other forms of gearing.

[There is a possible form of tooth which may be given to the hyperboloid pitch surface, so nicely shown by Mr. Arthur, which will give the constant angular velocity required and will permit, as well, the sliding action described as taking place between the two gears. This form of tooth, invented by Olivier, is described in Grant's "Treatise on Gear Wheels," paragraphs 175 and 176. It has no practical use, however, since it vanishes to infinitesimal dimensions at the smallest diameter of the gear, and has a great obliquity of action at the larger diameters. A modification of this form of tooth

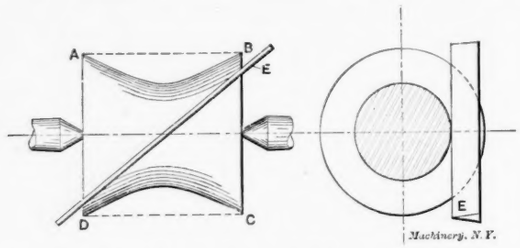


Fig. 4. Generating the Hyperboloid from a Straight Line.

was devised and tried by Mr. Beale of the Brown & Sharpe Mfg. Co., but, while it has great scientific interest, the form has little practical value, on account of the small size and weakness of the teeth and the difficulty of generating them. Considerable information is given in the book referred to above in relation to the determination of hyperboloid pitch surfaces for various shaft angles and velocity ratios. The spiral gear, however, with the exception of the worm gear, appears to be the only practical solution to the problem of connecting by a single pair of gears two shafts not in the same plane.—EDITOR.]

* * *

In the days of our forefathers, when rifle balls were spherical, and long, cylindrical, conical-headed bullets and rifled barrels were undreamed of, the gunsmith adopted a curious but convenient method of designating the gage or diameter of the bore. He expressed it by stating how many bullets, of a size that would fit a particular musket, would go to make a pound. Thus, a 10-bore musket would be one of such a bore that ten of its bullets would go to make a pound weight; a 16-bore gun would be one whose bullets would run sixteen to the pound, and so on. Hence we get the anomaly, that the larger denomination musket has the smaller bore. Although the day of the spherical bullet has long passed away, and the only smooth-bore remaining is the shotgun, the old method of designation has been retained until the present time.—*Scientific American.*

MAKING SMALL RELIEVED GEAR CUTTERS IN THE SLOAN & CHACE SHOPS.

The machinist who has been accustomed to the ordinary run of work, say that included in the range between the sewing machine and the ocean steamer, is likely to feel himself better acquainted with anything between these two extremes than he is with work that tends toward the microscopic, such as the making of tools and parts for clocks and watches, for instance. One of the things which aroused the particular wonder of the writer while he was still an apprentice to the machinist trade, was the minuteness of the formed and relieved gear cutters which he saw in a clock factory to which he had made a casual visit. Even taking for granted the use of the magnifying glass in making these cutters, how could the hand of the toolmaker be kept steady enough to draw correctly the proper outline or file a templet or form tool to that outline after it was drawn? With this perplexity of his apprentice days still in mind it was with renewed interest that he watched the methods used in making these small cutters in the shops of the Sloan and Chace Mfg. Co. at Newark, N. J.

In the first place, of course, there is no direct use of hand work in the actual forming of the outline of the cutter, or the form tool with which it is made. That is to be expected, and the pantograph idea would at once occur to a mechanic as being the most suitable principle to use in obtaining cor-

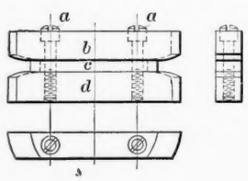


Fig. 1. A Built-up Form Tool.

Fig. 2. Design of a Minute Formed Cutter.

rect outlines on the very small scale which has to be used. The way in which the pantograph idea is applied, however, is very ingenious, and all of the tools used in the production of these cutters show evidence of being the result of thought and experience. It must not be imagined, however, that these machines are new. They are none of them new, some of them being as old as twenty years or more. Their age, however, does not detract from their interest, and their

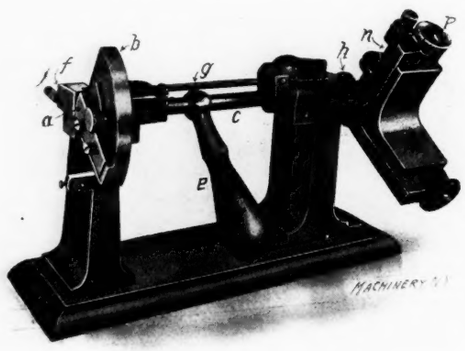


Fig. 3. Pantograph Machine for Lapping Form Tools.

construction and operation will without doubt be a matter of absolute novelty to the greater number of the readers of MACHINERY.

Fig. 1 shows the form tool with which the cutter is shaped and Fig. 2 shows the general type of cutter produced. After the blank has been turned up, angular saw cuts are made in its periphery to furnish a clearance space to run the emery wheel into when grinding. The ends of the projecting tooth

thus formed are then finished off to a radial line, and the blank, with the general outline shown in the cut, is ready for the relieving lathe, where it is formed by the tool in Fig. 1. This tool, as shown, is made of three parts held together by screws *a a*. Of these three parts, *b* and *d* are identical so far as the shape of their cutting edges is concerned, but are reversed in form, one being right-hand and the other left-hand. At *c* is a filling piece which forms the top of the cutter and separates the two side pieces to give the proper width

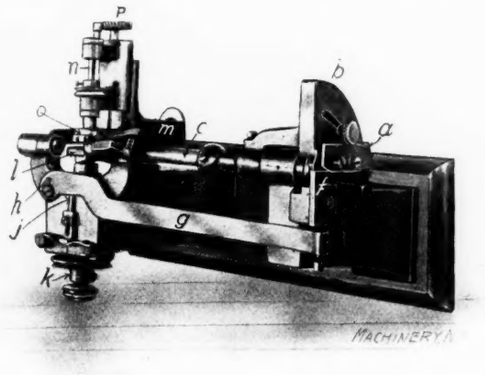


Fig. 4. Top View of Pantograph Machine.

to the top of the cutter and the bottom of the tooth space. Piece *c* is made by direct measurement; in forming the curved outlines on pieces *b* and *d*, the pantograph machine comes into play. The double-ended design of the tool is inherent in the construction of the pantograph machine, and gives it the advantage of a double life, since when one end is worn out the tool may be reversed, when the same form will be found at the other end.

The construction and operation of the pantograph machine will be understood from the photographs which are reproduced in Figs. 3 and 4. In these two views similar parts have been given the same reference letters. At *a* is a templet whose edge has been worked out to the desired outline for the side of the tooth for which the cutter to be made is intended. This outline is made on a scale of 10 to 1, this reduction being great enough to avoid any greater irregularities than would be produced by the most perfect mechanical methods possible. Templet *a* is fastened to a sector *b*, which is in turn attached to a shaft *c* and may be rotated with it by handle *e*. The templet *a* bears with its working edge upon another plate *f* which, as handle *e* is rocked up or down, transmits the motion received to the reducing lever *g*, which is pivoted at *h*. At a point one-tenth of the distance from *h*

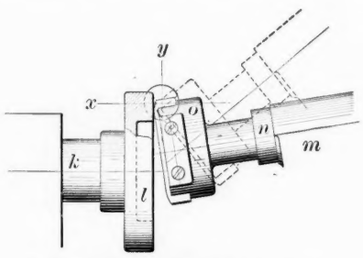


Fig. 5. Action of Diamond Lap on the Tool Blades.

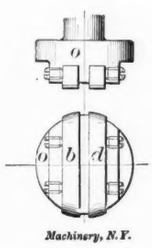


Fig. 6. Chuck for Holding Tool Blades.

to the bearing point on the plate *f* a contact pin *j* bears upon the lever, this contact pin giving the reduced motion due to the rotation of form *a* to a spindle *k*, driven as shown by a grooved wheel at its outer extremity. This spindle carries on its inner end a lapping plate *l* shown in detail in the line cut Fig. 5. This lap has its plane front surface charged with diamond dust and is the cutting member employed in shaping the form tool blades. To the further extremity of rock shaft *c* is attached a bracket *m* with suitable adjusting slides. This bracket carries a second revolving spindle *n* driven by a round belt and carrying on its inner end the chuck *o* which carries the two blades, *b* and *d* of Fig. 1, which are to be ground. These blades are held in transverse slots in the face of the chuck, being tightened in position by the headless set-screws shown. This construction will be more plainly understood by reference to line cuts 5 and 6. It will now be evident with a little thought, that, with the machine properly adjusted and the lap, tools, and templet in place as shown, if spindles *k* and *n* are revolved, the handle *e* rocked up and down, and the cross slide screw *p* fed in slowly, the outline of templet *a* will be reproduced by lap *l* on tools *b* and *d* on a scale one-tenth of the original. The intersection of the axes *x* and *y* in Fig. 5 represents the center line of the rock shaft *c*. The revolving of shaft *o* continues this form in a circular direction about the center of rotation so that *b* and *d* practically form parts of a circular form tool which may be ground in the same way that a circular form tool is without losing shape. The tools *b* and *d* are of course hardened before this operation is performed. Filling piece *c* shown in Fig. 1 is simply a portion of a plain circular disk.

After the form tool has thus been made and assembled, a blank for the cutter, made as shown in Fig. 2, is placed in the relieving machine in Fig. 7 where the outline of the form tool is given to it. All the motions of this machine are driven from pulley *a*. The further end, not shown, carries the first of a train of change gears meshing with large gear *b*. These change gears may be arranged to give, if the cutter for instance is to have twelve teeth, twelve revolutions of *a* to one of *b*. Shaft *c* carries, just back of pulley *a*, a cam which acts on a roller at the further end of lever *d*. This

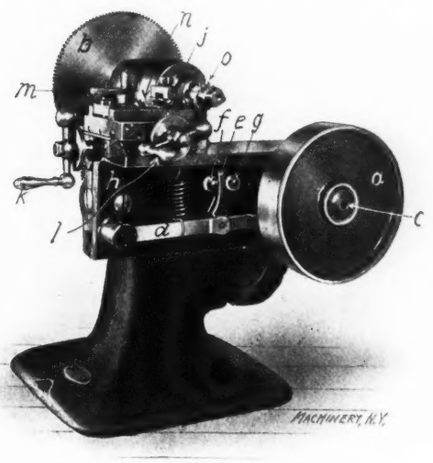


Fig. 7. Relieving Machine for Minute Formed Cutters.

lever has pivoted to it a little wedge *e* which works between stationary roller *f* and roller *g* which is fast to slide *h*. It will thus be seen that a suitable in-and-out motion for the relieving of the teeth is given to slide *h* by the rotation of pulley *a*. Slide *h* carries the tool post *j* and the two slides and their adjusting screws operated by handles *k* and *l*. The tool post *j* has also a tipping adjustment controlled by thumb-screw *m*. Form tool *n*, made by the process previously described, is placed in the tool post while the blank is held at *o* on the front end of the same spindle which carries dividing wheel *b*. The operation of the machine and the various adjustments of which it is capable will be easily understood from the cut.

It will be seen that, with this way of making, the only hand work involved in giving form to the cutter is that employed in shaping the outline of templet *a* in Figs. 3 and 4, and since this is done on a scale ten times actual size there is little chance for error. Of course the various adjustments have to be intelligently made. For instance, in the pantograph machine, the longitudinal position of lap *l* must be such that, when bearing plate *f* is moved into the center line of rock shaft *c*, the face of lap *l* will also pass through the same center line or be coincident with axis *y*, shown in Fig. 5. To provide for this, plate *f* is located on the center line and a circular plug milled down to its axis is inserted in a hole

at the further end of shaft *e*, when the lap is adjusted by the nut at the outer end of shaft *k* until it is exactly in contact with it. The necessary adjustments will suggest themselves from the various stops and screws shown in the cuts.

Such cutters as those we have just been describing will do for comparatively coarse gears and pinions, for use in the cruder sorts of time-keeping apparatus, such as alarm clocks, common eight-day clocks, etc. For fine watch gears, however, nothing but the slow-cutting single-tooth fly cutter is used. No matter how painstakingly a multiple-tooth cutter may have

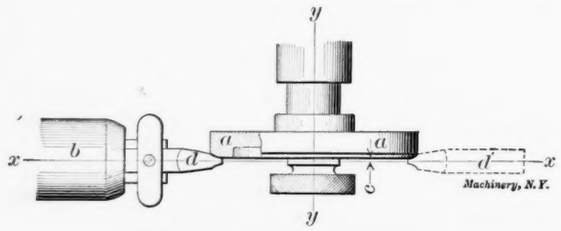


Fig. 8. Method of Lapping Fly Cutters.

been made and mounted in the machine it is to be used in, it will always run out sidewise more or less, and this means that the width of the space will not be a constant quantity. Each time the cutter is removed to be sharpened or each time the machine is set up, a different thickness of tooth will be cut. This error, of course, does not appear in the action of the fly cutter with its single cutting edge. The way in which the pantograph machine is used to make a fly cutter will be understood by reference to the line cut Fig. 8 and the halftone cut of the lapping machine in Fig. 9. At *a* is a lap with its front face formed to the required tooth curve. To give it the form desired, it was mounted at the end of spindle *n* in the place occupied by chuck *o* in Fig. 5. The tooth curve was transferred to it in the same way that the cutters are shaped, the action of lap *l* on this second lap *a* being identical with the action of lap *l* on blades *b* and *d*. Referring again to Figs. 8 and 9, *b* is an arm swinging in a horizontal plane on a vertical axis at the intersection of lines *x x* and *y y*. The distance *c* from axis *x x* to the face of the lap is made equal (when the lapping has finally been completed) to one-half the width of the tooth space at the root of the tooth. The fly tool *d*, which is being lapped into shape, is held by a collar and setscrew in a suitable recess formed in the end of mandrel *e*, which is placed in bearings on arm *b*. In operation, with lap *a* revolving, the arm is swung around

Fig. 9. Machine for Lapping Fly Cutters.

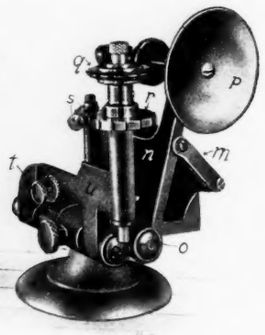


Fig. 10. Machine for Grinding Formed Cutters.

until the lap is in contact with tool *d*, when, being charged with diamond dust, it gradually under gentle pressure works it down to the form required. When one side has been thus shaped, arm *b* is swung around its vertical axis until the fly cutter is brought to position *d'* on the other side of the lap, when the other side of the tool is also formed.

To give the side relief required, an arm *f* is fastened to the outer extremity of spindle *e*. The lower end of this arm has a notch in it which is somewhat larger than the pin enclosed by it, which is driven into slide *b*. When the tool is pressed up against the lap in the position shown in Fig. 9, the lower end of this arm *f* is pushed over until this side of the notch is in contact with the pin; likewise, when, on the other hand, arm *b* is swung around to the right-hand side of the wheel, the arm is pushed over until the other side is in contact with the pin; thus spindle *e* is rotated very slightly to give clearance to the sides of the cut. The other adjustments of this machine will be readily understood. Provision is made for endwise movement of the spindle carrying lap *a*, to bring dimension *c* correct as shown in Fig. 8. Stop screws *g g* are provided, which accurately limit the swing of arm *b* in either direction to 90 degrees either side of *y y* as is required. Set screw *h* brings the cutting edge of the tool *d* in proper relation with the center line of the lap spindle. Means are provided at *j* for the very important adjustment requiring that the center line of the pivot on which arm *b* rotates shall exactly intersect axis *y y* of the lapping spindle. The fly tool is made with a triangular body which assures its being fastened always in its holder in such a way that the front cutting face is parallel with the axis of rotation.

In Fig. 10 is shown a little grinding machine used for sharpening form cutters. This operation will be readily apparent. From a pulley, not shown, motion is given to a crankshaft at the rear of the device which through crank *m* rocks frame *n* about pivot *o*. This frame carries a cupped emery wheel *p*. The cutter to be ground, shown at *q*, is mounted on the end of a vertical spindle carrying a ratchet *r* having the same

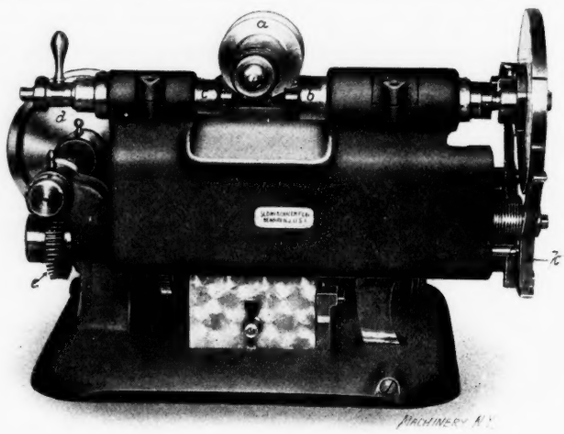


Fig. 11. Front View of Automatic Clock and Watch Pinion Cutter.

number of teeth as the cutter. Pawl *s* acts as a stop for the ratchet. Adjusting screw *t* furnishes an inward stop for frame *u* which is also pivoted at *b*, thus regulating the depth of the movement of emery wheel *p*. As the emery wheel is swung in and out by the crank, the hand of the operator indexes the cutter, stopping each tooth of the ratchet in turn against pawl *s*.

The machinery in which clock and watch gears are cut is interesting in a number of respects. Figs. 11, 12 and 13 show three views of an automatic pinion cutter made by the Sloan & Chase Mfg. Co.; of these Fig. 11 shows the working side of the machine. The pulley which drives the cutter spindle is shown at *a*. The work (which may be either in the form of staffs with pinion blanks integral with them, or in the form of blanks mounted on arbors) is gripped at either end in chucks *b* and *c*, the one at the headstock end and the other at the tailstock end. These two spindles and the work held by them are indexed by the mechanism at the right in this view. Pulley *d* drives the feeding and indexing mechanism through the worm gearing shown at *e*. This worm gear drives a shaft on which are mounted the various gears and cams for controlling the movements, which are shown to better advantage in Figs. 12 and 13. Indexing cam *f* is fast to the cam shaft just mentioned. As it revolves it comes in contact with tappet *g* on the indexing lever *h*, which, by means of a pawl rotates a ratchet fast to the work spindle. On its inward movement, before the pawl strikes the ratchet tooth, the dog *j* at the lower end of lever *h* withdraws the locking lever *k*

from the notch in the indexing dial, to permit the rotation to take place. Continuing, the forward movement of the indexing lever *h*, as it rotates the spindle through the pawl and ratchet described, brings the upper end of dog *j* in contact with a stop screw which releases the locking lever *k*, allowing its detent to drop into the notch on the periphery of the dial the moment the rotating movement has ceased. As the motion of the indexing cam is continued in the direction shown, the lever *h* returns to its normal position, dog *j* again dropping over the lower end of lever *k* as in the cut. The feed cam *l*, acting through the feed lever and the connecting link shown, gives the required horizontal movement for feeding the work past the cutters.

The machine shown is provided with a movement much used in watch gear cutting to insure extreme accuracy in the shape of the teeth, modified for this particular machine with considerable ingenuity. Three cutters may be mounted side by side on the cutter spindle. The first for taking a roughing cut, the second for an intermediate cut, and the third for the final finishing. The blank is first roughed out all the way around, then the second cut is taken, winding up with the finishing cut. The slide *n*, on which the spindle is mounted, being advanced each time an amount sufficient to bring the cutter desired to a position central with the axis of the work. At *o* in Fig. 12 is shown a six-tooth ratchet attached to a short shaft carrying three cams, located under the outer end of the spindle slide. These cams are so arranged that, as the ratchet is rotated, for each sixth of a revolution one after another of the three acts upon the inner end of one of screws *p*, thus giving the slide a longitudinal position dependent on the adjustment of the screw *p* which is being acted on at the time. Lock screws *q* are provided as shown for fastening screws *p* in position. Since the cams driven by ratchet *o* are double, the same cycle of three positions is followed in the second half of its rotation that occurred in the first half. A stiff spring keeps the spindle slide *n* in as advanced a position as is allowed by the cams and stop screws.

The action of the mechanism which changes these stops will be understood by comparing the Figs. 12 and 13. Stop dog *r* is rotated by a shaft passing through from the opposite side of the machine. This shaft makes a revolution for each revolution of the work spindle, being driven by an intermittent

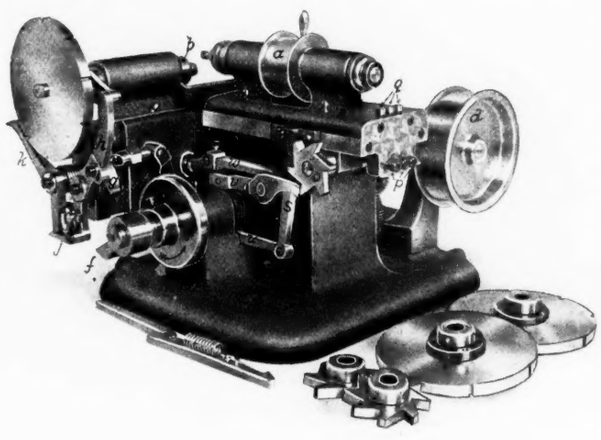


Fig. 12. Side View showing Indexing and Feeding Movement of Pinion Cutter.

gear, not shown in the cuts, from the shaft on which cams *f* and *l* are mounted. This gearing is adjustable to suit the number of teeth being cut. As this dog revolves, at the conclusion of the roughing of the teeth, it gives a sixth of a revolution to ratchet *o*, bringing a new cam and stop screw into action and centering the second cutter over the work. At the conclusion of the cut with that cutter, another sixth revolution is given to *o* in the same manner, when a third cam is presented which brings the new or finishing cutter into central position. It will be noted that by means of screws *p* the adjustment for each of these cutters is independent of the rest.

Provision is made for adjusting the depth of cut of the three cutters independently also. Lever *s*, with its fulcrum at *t*, is acted upon by the movement of the cutter slide in and out, as it brings the three different cutters into position. Rod *u*, attached to the lower end of the lever, carries on its further end three stop screws for the vertical motion of the work-holding slide on the front of the machine frame. The slide is elevated through the action of levers *v* and *w*, moved by a cam on the operating shaft, which mechanism serves to relieve the cutter on the return movement as well as to alter the adjustment when the cutters are changed. The depth of cut for each operation is determined by the three stop screws just mentioned, the one in action depending on which of the cutters is working at the time. These screws are not plainly visible in the cut.

A little thought will show that a pinion or gear cutting machine of the type shown in Figs. 11, 12 and 13, is very much

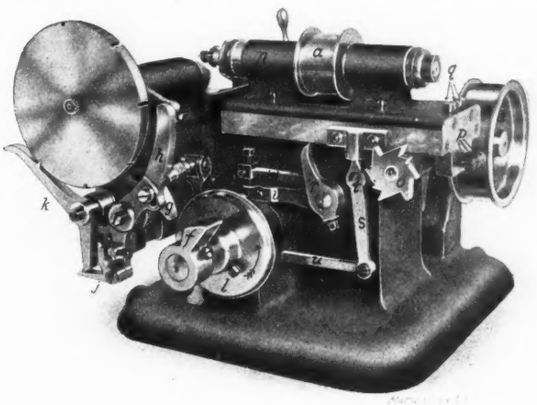


Fig. 13. Side View showing Operation of Cutter Shifting Mechanism.

more costly in proportion to its weight than the larger automatic gear cutters with which the machinist is familiar. There is, as we all know, no such thing as a perfect fit. When the slides and journals of a machine tool are fitted together, an amount of care is used depending on the purpose for which the machine is intended. If a three-pitch cutter is to be used on steel castings, a certain allowance, determined by experience, is made in fixing the diameters of the journals of the cutter spindle and box or bushing in which it revolves. The space left between the journal and the somewhat larger bearing is the oil allowance, and is filled with the lubricant provided for the bearing. If the fitting were more carefully done and a smaller allowance made at this place, not only might this oil allowance be too small to insure a film of lubricant over the whole bearing surface and so give rise to the danger of roughing it up, but the extra accuracy thus obtained would be a useless as well as an expensive luxury, since the heavy strains imposed on the structure of the machine by the action of the large cutter on the hard metal would produce deflections great enough to make of no avail the slight gain obtained by the means just described. In general, the lighter the parts are which are to be machined, the more accurately the machine may be made and must be made. In the case of a minute watch gear, an error of one-fourth of a thousandth in any dimension is a matter of as much importance as a sixty-fourth of an inch would be in the back gearing of a 28-inch lathe. Not only is accuracy thus a necessity, but the conditions that make it necessary also make it possible. In this smaller work, the slight strains imposed by the cutting action are almost lost in the comparative stiffness and rigidity of the framing of the machine, thus giving a chance for accuracy in fitting of the wearing surface to show its full measure of usefulness. The consequence is, that a carefulness of fitting in machines of this type is demanded and obtained, which makes them as expensive to build and purchase as ordinary gear cutting machines of far greater size.

* * *

It is reported from St. Petersburg that an official inquiry at Tomsk into the conduct of the Siberian Railway during the war has brought to light the fact that the government was at one station alone defrauded of $350,000, and that, on the whole line, some 1,500 cars disappeared!

VITAL NEEDS OF EVENING SCHOOLS FOR INDUSTRIAL WORKERS.

A. D. DEAN.

The next educational move in the immediate future will, I venture to say, be in the direction of improving the instruction in evening schools. Their methods should be recast. They should adapt themselves to modern industrial conditions, and through proper instruction of practical subjects touch more closely the economic and social life of the times. The evening school student attends to satisfy a definite need. Through meeting this need, a more permanent need will be created. These students have already received a more or less formal education in the public schools. They are receiving in their daily work incidental experience, and have learned from this thorough teacher that they are deficient in some lines; hence this endeavor, outside of their working hours, to fit themselves for definite lines of activity.

I shall outline what I consider to be vital needs in the organization and methods of conducting evening school work. The evening school deals with two rather distinct classes: First, those who are naturally students and seek with a definite purpose educational advantages in lines of general education; second, those who are not naturally students and yet who seek with a more or less definite aim educational help in a solution of some present problem which involves special service.

Courses Must be of Two Kinds.

The recognition of these two classes means that the courses of instruction must be of two kinds, one comparing favorably with the day school work in its general scheme, the other and major part differing decidedly from the methods ordinarily pursued. The evening work of the non-student class must have its own distinct ideals, methods, and estimates of value based upon current community conditions and individual needs rather than based on the regular school standards which are applicable primarily to the student class.

Day school teachers are employed too much at present in evening schools. These teachers can meet the needs of the student class, but they cannot properly teach the non-student class. I believe that to the custom of employing day school teachers must be laid much of the lack of definiteness in the planning of evening school work. It is a very simple matter for the average day school teacher to adopt the regular text books, and to use the regular outlines and methods. This is a perfectly consistent action, for few regular teachers have opportunity to know the vital needs of their students through their own experience. In some cities where it has not been deemed wise to employ the day teachers, the policy has been to engage young students of law, undergraduates of colleges, and retired teachers to do this most important work. Now the only people competent to teach in our evening schools are the men and women who know from their contact with modern industrial and commercial life vital points of interest which concern these workers who come to the evening schools to meet definite needs.

Evening School Instruction Must Appeal at Once.

Evening school instruction must appeal to the student immediately at the beginning of his work. The subject matter of the early lessons must satisfy his need as he has defined it. This statement may appear radical, but on second thought it will be seen to be true. For example, a young machinist has received a reprimand from his foreman because he cannot read a working drawing with sufficient skill to do properly his daily work. He enrolls in a drafting course to meet that deficiency and finds that the first two lessons are concerned with lettering plates, the next three with drawing straight and curved lines and the handling of instruments, and that the remainder of the term is to be spent on the projection of points, lines, surfaces and solids. During this time he is receiving in his daily work the same reprimands, and is therefore debating in his own mind the value of his evening instruction. It is undoubtedly true that the drawing course I have here outlined, is a proper one for teaching mechanical drawing for those who are to be draftsmen, but the average apprentice machinist does not see the direct application of this instruction to his work. He enrolled for a definite purpose. To be sure it was a narrow one, but nevertheless it had economic value to him. It would have been perfectly possible to give in the first evening some elementary instruction in the reading of simple drawings; to teach him in five lessons where to look for the dimensions denoting length, breadth and thickness; to have shown the principles of simple sectional drawings and to have him comprehend the laying out of holes for drilling. Instead of leaving school at the end of the fifth lesson with no instruction which appealed to him, he would have received enough in those five lessons to fit him to meet the needs of his foreman, and more than likely he would have remained in the drafting class to receive the more definite and thorough instruction in the theory of mechanical drawing such as must be gained if one is fully to comprehend and cover the entire range of the subject. Give to the apprentice the kind of training that will make him a good apprentice and when this point has been reached there will arise a need for another type of training suitable for the next grade which he hopes to attain.

Courses Must be Elective and Flexible.

The various features of the course must be elective and flexible and presented in small and varied units. Instead of printing in a course of study "Arithmetic," "Geometry," etc., there should be printed, "Arithmetic for Mechanics," "Arithmetic for Clerks," "Mechanical Drawing for Apprentices," etc. Where it is possible even a finer differentiation is desirable, such as "Arithmetic for Plumbers," "Arithmetic for Errand Boys," "Mechanical Drawing for Machine Tenders," etc. Not only will this presentation serve to catch the eye of the prospective student, but it will also suggest to him that special effort is to be made in the class work to help him in his daily occupation.

The instruction in the various branches must be adapted to the needs of the various occupations. The terms used in the class room must savor of the shop, office and store. From personal experience, I know that the problem, "What is ¾ths of 37½?" does not appeal so much to a clerk as the problem, "What will ¾ of a yard of cloth cost at 37½c. a yard?" On the other hand, the latter problem does not awaken the interest of the mechanic as much as the problem involving the same operations, which reads, "If a copper casting weighs 37½ pounds and specific gravity of iron is ¾ that of copper, what will the casting weigh if made of iron?"

Departmental System not Suited.

The student will do better work if the instruction in the related branches of certain occupations is given under one teacher, rather than under the departmental system of specialists in each branch. The student should not elect more than two or three subjects, the major one, bearing directly upon his daily work, the other somewhat related to the main one. It is this major subject which has drawn the student into the school and it is this which will keep him there if along with it one or two allied subjects are taught in a practical manner by the teacher of the major subject. The student will understand better the connection between these subjects because the teacher has himself a clear conception of the relationship. A machinist enrolls in an evening school for mechanical drawing and finds that he needs to "brush up" in fractions and decimals and that he needs "square root" in order to work out a formula for screw threads. I know of no time more opportune to teach him these topics than when the need for them arises, and none is more qualified to give the required practical instruction in such topics than a competent drawing teacher. When large classes demand assistant teachers, these assistants should be assigned to teaching applied mathematics through individual instruction at the drawing table or else to giving instruction to small groups in an adjoining room, keeping before the mind of the student the direct connection between arithmetic and mechanical drawing. When the student has reached a place in a drafting course dealing with the subject of screw threads, it becomes necessary for him to apply some such formula as $P = 0.24\sqrt{d} + 0.625 - 0.175$, where P is the pitch of the thread and d is the diameter of the bolt. This problem involves square root and decimals.

One hour of individual or small group instruction by the drawing teacher will give a student the necessary familiarity with these mathematical processes to make them sufficiently clear to him in application to the formula. That many students are not satisfied with this hasty and incomplete instruction has been my experience, and this is often made evident through their joining the regular class in mathematics the next year in order to gain an insight into the reasons involved in the process of square root. Instead of thorough preparation in mathematics for mechanical drawing I should have the mechanical drawing lead the students into mathematics. This reversal of the usual procedure, while it may not be pedagogical so far as the subject matter is concerned, is certainly true to experience when one deals with the characteristics of the average evening school student.

Sequential Arrangement of Courses Needed.

Evening schools should have a sequential arrangement of courses. If the student's transient need is well met, it will place him in a better position, only again to make him feel a renewed need of self-improvement. This means that he will return to the evening school in some subsequent year when he ought to be given advanced work. My own experience has taught me that evening schools are so overcrowded in the elementary courses and are trying to do so much to raise a student one round in the economic ladder that these advanced students suffer through insufficient attention. If specially provided for, they might become our foremen, superintendents and managers. Not only must each school-year's work be driven home and clinched, but each series of years' work be so clinched as to meet the needs of the captains of industry, who are demanding thoroughly trained men for foremanships.

Need of Recreative Element.

Evening schools often fail to have the subject matter and its treatment glow with the recreative element. We must offer educational features in connection with physical and social privileges. The continued interest of many people is often times dependent upon identification with an associated group of varied privileges offering not only self improvement, but recreation. School buildings in our large cities equipped with libraries, gymnasiums, assembly halls, and lunch rooms should be open from 5:30 to 10 P. M. The students should be allowed to enter the building immediately from their work, be furnished a lunch at a low price, encouraged to avail themselves of bathing and library privileges, and have the opportunity for social intercourse as well as educational classes. Under modern industrial conditions it must be remembered that the employed work under a stress which is nerve wearing and physically exhausting. Oftentimes teachers in evening schools complain of general dullness as expressed by nodding heads and listless manner. If they would stop to think of the long distances traveled between shop, home and school; hurried supper; the stifling atmosphere of the school room and the glow of the electric lights, they would readily see the reason for this dullness. The general introduction of the eight-hour day, while it would make work strenuous in the extreme, at the same time shortens the day's hours of labor and ought to bring more opportunity for recreation and education. It is a duty of the evening school so to combine these two features as to result in the profit of the worker. At present young people seek recreation independently of education much to the loss of their own best interests.

Need of Division of Classes by Ages.

There should be in the evening school work a separation in the class instruction of the immature from the mature non-student class. The latter are extremely self-conscious. They are often embarrassed at having to be instructed after passing the usual school age. Their feelings should be respected as far as possible. Is it any wonder that a foreman of a pattern shop does not take kindly to being instructed in mechanical drawing in the same class with a boy machine-tender over whom he has charge during the day? This point does not have to be considered in the German continuation schools where the ages of the students are more uniform. The young men in some parts of that country are required to attend evening schools for a definite period and consequently the grading of men according to ages is unnecessary, for a young man of sixteen in the elementary class is in contact with those of similar age, and the more mature men in advanced classes, having already received elementary training, are likewise graded with those similarly prepared.

Special Text Books Suited to Evening Schools.

There should be a series of textbooks written expressly for the kind of instruction demanded in evening schools. That few such books are on the market is clear testimony that as yet a small number of teachers have recognized that there is any difference between the methods of instruction in day and evening schools. When the fact is recognized, a series of books will be published. In a careful study of the value of existing textbooks meeting the needs in all branches of one class of men, *i. e.*, men engaged in the machine trades, I have been chagrined to find that I could readily count the entire list upon the fingers of my two hands. What is needed is, for instance, not an elaborate textbook in general arithmetic with all its topics of fractions, decimals, square root, percentage, interest, partial payments, etc., but rather a book which appeals to a man in the machine trades, then one which appeals to a plumber, or a clerk, or an errand boy; small enough to slip into the side pocket of a coat and cheap enough so that he can readily own a copy for reference in his daily work.

Provision for Irregular Attendance.

Provision should be made for students who can attend but once or twice a week. Some students stay away because they cannot attend "regularly." This applies to all domestic servants. It applies also to many industrial workers. In prosperous times shops are run evenings and the men employed are expected to work over-time. They can usually get away for one night in the week during such times. They cannot always tell definitely what nights they will be called upon to work.

I know of a few schools which allow their members to attend any night or nights during the week after the work is fairly started. Such a plan is perfectly feasible in shop or drawing courses where all the instruction is individual. Some schools allow the students to do their drawing work at home during the periods of overtime work in the shop, expecting that the students will attend some night in the week to get definite instruction or data for home work.

Classification by Vocations.

Students must be classified into vocational classes according to their trade or business. The old workingman's guilds were founded for the purpose of social intercourse and mental stimulus. Each trade had its own guild. The daily trade experiences of each member became the property of all members. Discussions relating to the practices of their chosen trade occupied their attention. Is it not true that working men to-day have common trade interests? Evening school students grouped according to occupation would have an opportunity to talk over these interests. The teacher could act as a leader and draw out the students into telling their trade experiences and through the expression of these various opinions the most practical solution of the particular problem at hand would be obtained. Teachers who have had evening school experience know how difficult it is to get the students to recite and express themselves at the blackboard. A free discussion of the point at issue makes the student lose his self-consciousness and before he is aware of it he is at the board illustrating his particular method of solution. Of course such discussions must be under wise guidance.

Fee System Preferable to Free Instruction.

While it may not be feasible to charge in the public school system a small fee for the evening work, at the same time I know from personal experience that such a procedure is very desirable. That the working people can afford to pay for such instruction is evident from the large numbers who are subscribing to various correspondence school courses, and also from the fact that 69 per cent of the parents interviewed in a recent investigation conducted by the Massachusetts Commission of Industrial and Technical Education stated that

they could have afforded more schooling for their children had it been of a more practical kind. A self-supporting person appreciates what he pays for and is not only more anxious to finish his course after he has paid for it, but is also quite likely to see to it that the teachers give him what he wants. The fee system acts as a stimulus to the student and teacher. It is not necessary to charge a fee covering the entire cost. German evening schools charge only a small fee. There should be no charges for administration, lights and heat. The instruction might also be free, the school charging only for the material consumed in the shop and laboratory courses. Many superintendents of schools have expressed a wish that some fee might be charged in evening schools simply because it assists in obtaining better attendance, more earnest work, and "weeds out" those who diminish the efficiency of the school.

Evening Classes should be Attractively Advertised.

There is a need of recognizing that in adapting educational features to peculiar conditions oftentimes conservative methods will not meet the personal attitudes of those who need the service. In the matter of presentation before the public it might be well for the public schools to imitate some of the advertising methods of our more successful correspondence schools. It is not a wise business policy for a city to spend $10 on the instruction of a student when with an additional 10 cents' worth of advertising the cost per pupil could have been reduced perhaps to $8 because of the larger number enrolled and hence lessened the cost per capita chargeable to the general items of administration, heat, light and interest. Neither is it the best policy for school authorities to insert a small, obscure advertisement in the daily paper, unattractive in its wording, lacking explanation regarding the nature of the instruction and expect a working man or woman who needs such instruction to understand it or even see it. On the contrary it is good business for a city to advertise its educational features in an attractive poster on various billboards, in the office, factory and store.

Doubtless some time in the future men who are responsible for the proper conducting of evening schools will begin to realize that the desirable locations for many educational features are in the natural assembling places of the working people, especially during their leisure hours, making as much as possible the educational effort in which they participate a natural adjunct to their daily life and not a separate and distinct enterprise. I prophesy that small libraries and reading rooms, will be added to stores and factories and that practical talks and lectures will be given to the employees of these establishments. This procedure is possible probably only when there is no equipment necessary in connection with the instruction.

Growth of Correspondence Schools an Argument for Evening Schools.

The significance of the growth of correspondence schools in this country must not be lost sight of. Their rise denotes that the working people are seeking education when it is presented to them in such a way as appeals to them as meeting their needs and also when brought into close contact with their daily habits. Just so long as correspondence schools flourish, just so long will their presence illustrate the need of better evening schools. Let us consider the amount of money which goes out of the community into the coffers of correspondence schools. For instance, in Massachusetts it is estimated that there are 55,000 subscribers to correspondence schools. If on the average each subscriber has paid $40 for his course, that means that $2,200,000 has gone out of the state into the pockets of private enterprise in other states. There are 28 important industrial centers in the state of Massachusetts. This sum of money distributed to each of these centers would approximate $78,000, which at 4 per cent would net $3,120 a year. This estimate is very conservative as it only assumes that the money has already been spent and does not take into account that which is leaving the state every day as subscriptions to the various courses in these schools. The amount mentioned, if directly applied to the meeting of the economic needs of the working people through evening school instruction would give practical work of high order to over 300 students in technical and commercial work. It would mean an evening school of trades and an evening commercial high school in each of these 28 important industrial centers in addition to the regular elementary work now furnished by the municipalities. Is it not casting reflections on the cities when private enterprises take the field of educational activity which rightfully belongs to the public enterprise?

Public Schools not Meeting Present Needs.

More and more is it being recognized that the public schools are not meeting the needs of industrial life. One has only to note the tremendous growth of the correspondence schools, of the work done by the Young Men's Christian Associations with their forty thousand evening students, of the Cooper, Pratt, Lewis and Spring Garden Institutes with their class rooms and shops overflowing with evening students, the manufacturing concerns which are introducing apprenticeship systems, with evening instruction, to feel that there is a decided need for practical evening school instruction. If such education is not a function of the state, an inalienable right as it were, it might be well to acknowledge it. Is it not better to comprehend the significance of all these movements and find out the needs of the industrial workers and then meet the needs through progressive educational activity in evening schools?

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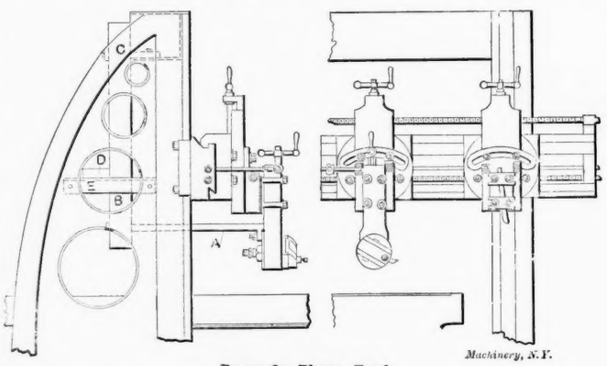
BRACE FOR PLANER TOOL.

The accompanying cut taken from *Railway and Locomotive Engineering* illustrates a brace for a planer tool used by the Pennsylvania Railroad Co. in their Columbus, Ohio, shops. It is said to have increased the output of a certain class of planer work about one-third. It is employed for planing out the circular seat on driving boxes for the brasses. This seat is not a full circle, there being two lips at the lower side for holding the brasses which prevent this work from being done on a lathe or boring mill; hence the practice is to either slot



Brace for Planer Tool.

out this part or to plane it on a planer using a "radius" tool of the form shown in the cut. The feature to which particular attention is called is the brace *A* which stiffens and supports the tool, preventing heavy torsional stresses being imposed on the planer cross-rail by the roughing cuts. Its principle is similar to the planer bar with stiff support, illustrated in the October, 1904, issue of this journal. The thrust is transmitted to the housings in a different manner, however, there being a vertical member *B*, pivoted at *C* so that it can swing through an arc of limited extent, and backed up by a cross member *D* which is secured to the housings by suitable connections, as at *E*. The mechanism for operating the planer tool through the arc of a circle is not described but we infer that it is automatic in operation as it could easily be made so.

* * *

A common abbreviated method of writing dates is to write the month, day and year, thus, 9/23/06 for September 23, 1906, but an objection is that if this method is to be used it should be in logical order, *i.e.*, the day, month and year. All do not follow the same order, the consequence being that this method of recording dates is unsafe, as in some cases it is impossible to tell which is the month or year. A method followed by one of our German correspondents is to give the day, month and year, but to write the month in Roman characters, thus: 5/XI/06, *i.e.*, November 5, 1906.

ADVERTISING MACHINERY IN LARGE ESTABLISHMENTS.

Firms advertising machinery as a rule send their catalogues to the main office of the manufacturing plant where they wish to introduce their products. As a rule they are addressed to the firm, no particular individual being referred to. In the case of a small concern this works very well, no doubt. The manager of the small concern is not only giving a great deal of his time to the direct supervision of his shop, and knows what may be particularly needed, but he as a rule has a thorough technical knowledge of the requirements put on machinery. His duties, while manifold, are within a more limited sphere, and he will find time to give some personal attention to the various advertising literature reaching the office. But the case will be found to have a different aspect when we consider a large establishment. In the first place a greater amount of advertising literature reaches such a place, and secondly, the persons in charge of the concern cannot possibly be either personally in touch with the particular needs of various departments, nor possess a thorough technical knowledge as to the merits of all the various machines and appliances used in their plant. Even admitting that their ability were of more than the usual kind, and that they had mastered a great number of various fields of information, their duties are so exacting that it is doubtful whether they would give much time to studying advertising literature unless being particularly interested in some certain line of machinery. Besides these considerations we cannot overlook the fact that the leading men of large establishments are as a rule more men of business than of technical achievements, and their judgment of machinery would be largely influenced by many other considerations than those of mechanical superiority. From what has been said we may thus conclude that in a large industrial plant the advertising literature if sent to the office, largely fails to exert due influence. If reaching the office in a busy season it often finds its way too quickly to the waste basket. The man who would be interested in the catalogues never sees them, and if they are filed and indexed, as is the case in most well organized shops, but by no means in all, they are still performing no useful service, being often kept in the file only until old enough to be thrown away.

The men who largely influence the management in regard to the buying of machines in large concerns are the foremen of the various departments. They know exactly the needs of their particular part of the shop; they possess an intimate knowledge of the requirements of the machinery they use, and their interest in building up the business is greatly increased by their partaking in the selection of appliances for facilitating the output. They are the men whom the advertising literature should reach. But seldom or never will it reach them unless they send for it themselves, because their own firm as a rule does not recognize the good of sending the received catalogues to the men who would be best able to judge, and the advertisers have not as yet realized the necessity of getting in close touch with those who actually are, or at least ought to be, most active in the selection of machinery. It is therefore a timely suggestion to put forth, that our advertising manufacturers should add a request when sending their catalogues, that these latter be placed in the hands of the man actually in charge of the class of machinery advertised. Some of our leading firms have in fact already adopted this method in regard to certain kinds of their trade literature, but in the majority of cases the foremen and even the department superintendents are depending entirely upon the advertisements in the trade journals, and the catalogues which they send for themselves on account of these advertisements, for all knowledge about new advertised machines on the market. If it were not for the influence of the advertisements in the trade journals, it is likely that our manufacturers would long before this have realized that catalogues need go further than to the business office of a firm. By means of the trade journal which reaches further, the advertisers have reached the men which they should try to reach by their catalogues as well.

A EUROPEAN BEVEL GEAR GENERATING MACHINE.

The bevel gear planing machine shown herewith, built by the Ateliers de Construction Mecanique (*cidevant* Ducommun) at Mulhouse, Alsace, embodies in its design a number of features of considerable interest, among which are the linkage system which gives the proper movement to the blank, and the use of two tools, one for each side of the tooth. This machine operates on what is known as the "Sang" system of gear generating which, in its simplest form as applied to spur gears, is illustrated in Fig. 2. The master wheel and the blank to be cut are given a lateral movement perpendicular to the axis of the shaft which connects them. This movement rolls the master gear over the rack, giving the blank a similar rolling movement over a pair of cutters which include a space corresponding in outline to the sides of the rack teeth. Thus these tools cut in the blank the tooth curves required to mesh properly with a rack whose teeth have the outline of the cutting tool edges. It is not necessary that a rack and master gear be used to give the rotary motion to the blank as its axis is translated. As shown in Fig. 1, when the pitch

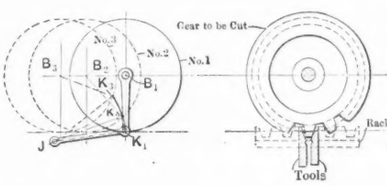


Fig. 1. Approximate Link Motion.

Fig. 2. Sang Method of Generating Spur Gears.

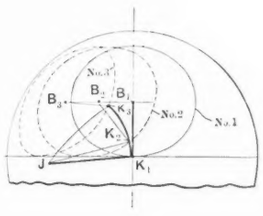


Fig. 3. Approximate Spherical Link Motion.

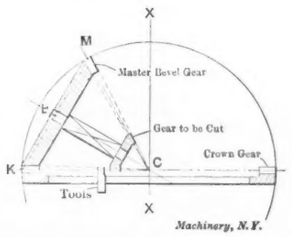


Fig. 4. Sang Method Applied to Bevel Gear Generating.

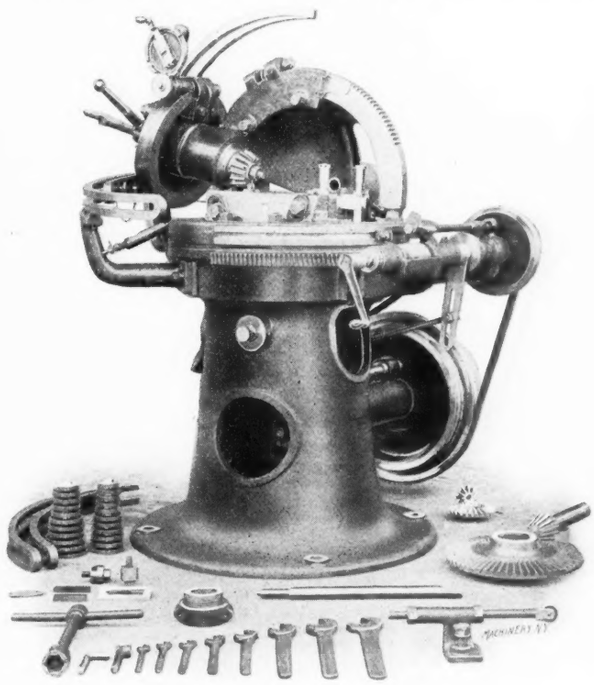


Fig. 5. A Machine Involving the Principles Illustrated in Figs. 3 and 4.

circle of the master gear rolls on the pitch line of the rack, a point such as K_1 in the pitch circle of the master gear will trace a cycloid K_1, K_2, K_3. A point J can be found so located that, with this as a center, an arc can be drawn very closely approximating the cycloid. If then, instead of the master gear and rack, we substitute as shown in Fig. 1 a crank $B_1 K_1$ in place of the gear, and a link $J K_1$ to connect the crankpin with the point J determined as above described, then, when the axis of the blank is given the lateral movement described in connection with Fig. 2, the link will so restrain the move-

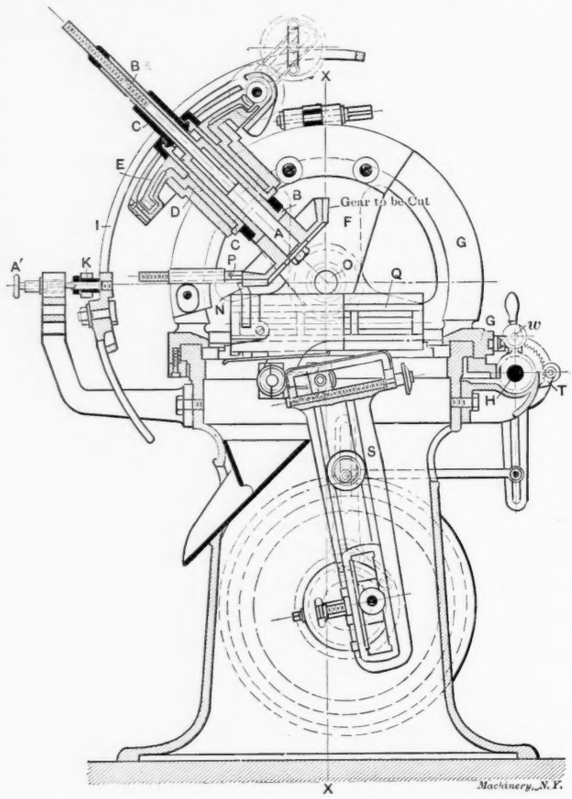


Fig. 6. Vertical Section through Plane of Work Spindle.

ment of the crankpin K_1 that it will nearly follow the cycloid and in so doing will give the blank a close approximation to the rotary motion obtained by the gear and rack in Fig. 2.

The Sang process as applied to the forming of bevel gears is shown in Fig. 4. The rack is replaced by a crown gear and the master gear is replaced by a master bevel gear whose axis passes through the central point of the crown gear. The gear to be cut is mounted on the axis of the master bevel gear and moves with it, and is so located that its pitch cone apex is at C, the center of the crown gear. If, then, the sides of the teeth of the crown gear be plane surfaces, a pair of tools with their cutting edges in the plane of the tooth faces of a rack space may be used to generate the teeth of the gear to be cut, when these tools are given a reciprocating motion which allows their cutting edges always to remain in the plane of the sides of the rack tooth. In this case the axis of the master gear and blank, instead of being given a rectilinear horizontal motion at right angles to the axis as in Fig. 2, is given a circular motion about vertical axis $X\ X$, so that line $B\ C$ would describe a cone if it were completely revolved. The master bevel gear is thus given the proper rolling motion about the crown gear.

By a similar approximation to that illustrated in Fig. 1, we may do away with the crown gear and the master bevel gear. The pitch circle of the master bevel gear rolls about the pitch circle of the crown gear. In so doing a point K_1 in the pitch circle of the master bevel gear will, as shown in Fig. 3, describe a spherical cycloidal curve determined by points K_1, K_2, K_3, which are the positions that point K_1 takes in the three positions of the pitch circle marked No. 1, No. 2 and No. 3 in the sketch. It must be remembered, in following this action, that all the lines shown are supposed to be drawn on the surface of a sphere with C (Fig. 4) as center. Now, as in Fig. 1, we find a point J such that, with one point of the dividers located here, the other point will follow the spherical cycloid K_1, K_2, K_3 very closely. We may then, as in Fig. 1, dispense with the master and crown gears, replacing them with a crank or link, $B_1 K_1$, pivoted at one end to axis $B\ C$, and joined at the other end at point K_1 to the swing link pivoted at J. With this arrangement then, within reasonable limits, a rotation of axis $B\ C$ in Fig. 4 about vertical axis $X\ X$ will impart to the gear to be cut, through the restraining action of link $J K_1$, a motion similar to that given by a master bevel gear and crown gear, which will be suitable, as before explained, for shaping the correct form of tooth on the blank under the action of the two cutting tools.

The machine, Fig. 5, uses two tools, one for each side of the tooth. Since these tools, shown at N in Figs. 6 and 7, must move in separate paths converging toward point O, they are necessarily mounted on separate slides traveling on guides Q, which may be adjusted independently about the vertical axis $X\ X$ of the mechanism, in the circular recess to which they are fitted in the top of the frame of the machine. This adjustment gives the necessary converging motion to cause the teeth which they form in the blank to disappear at the apex O of the crown gear and the blank. A separate adjustment, controlled by the tap bolts seen in the curved slots on the sides of the tool slide guides in Fig. 5, gives a rocking adjustment about axis O in the plane of the section in Fig. 6. This is required to make the tool follow the angle of the root of the tooth, and gives it a movement slightly out of the horizontal. The tool slides are reciprocated through ball pivoted connecting rods from slotted link S, which has the adjustment shown in Fig. 6 on its upper end for varying the position of the stroke, and an adjustable crankpin in its driving crank for varying the length of the stroke. The machine is driven through the three-step cone shown in Figs. 5 and 7.

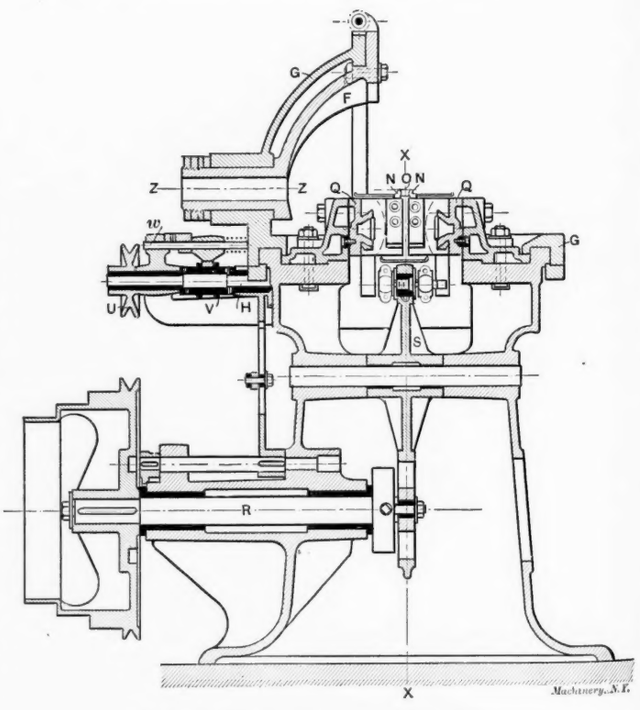


Fig. 7. Section showing Driving Mechanism.

Neglecting, for the time being, the adjustments required for suiting the machine to gears of different pitch cone angles, let us trace in the machine the action explained by the diagrams in Figs. 3 and 4. Axis $B\ C$ in Fig. 4 is that passing through the gear to be cut in Fig. 6. The rotation of this axis about the vertical axis $X\ X$ of the machine is effected by rotating the whole structure on which it is supported around the circular bearing provided at the top of the column of the machine. The table, carrying the structure for holding the gear blank, has a section for a worm wheel formed on a por-

tion of its periphery, as shown in Fig. 5. A worm on shaft H engages the worm wheel teeth. Shaft H may be driven either by pulley U, Fig. 7, from the belt cone for quick return movement, or by a cam in the face of the belt cone through the slotted link mechanism shown acting upon the ratchet and ratchet wheel at T, which arrangement gives the cutting feed. A clutch V connects either of these motions to shaft H. This clutch is operated by a rod w controlled by the dogs shown in Fig. 5, adjustable in the peripheral slot of the circular table. By means of these dogs the table, when started on the cutting feed, will stop itself at the conclusion of the cut and rapidly return to its first position ready for starting in on a new tooth.

So much for the movement about the axis X X. For the rolling motion which must be given the blank to agree with that of the master bevel gear rolling in a crown gear as shown in Fig. 4, the approximation outlined in Fig. 3 is used. Link I in Figs. 6 and 8 is link B_1 K_1 of Fig. 3. Point K in Figs. 6 and 8 is point K_1 in Fig. 3. In Fig. 8 pivot K has been raised from the position it should occupy directly back

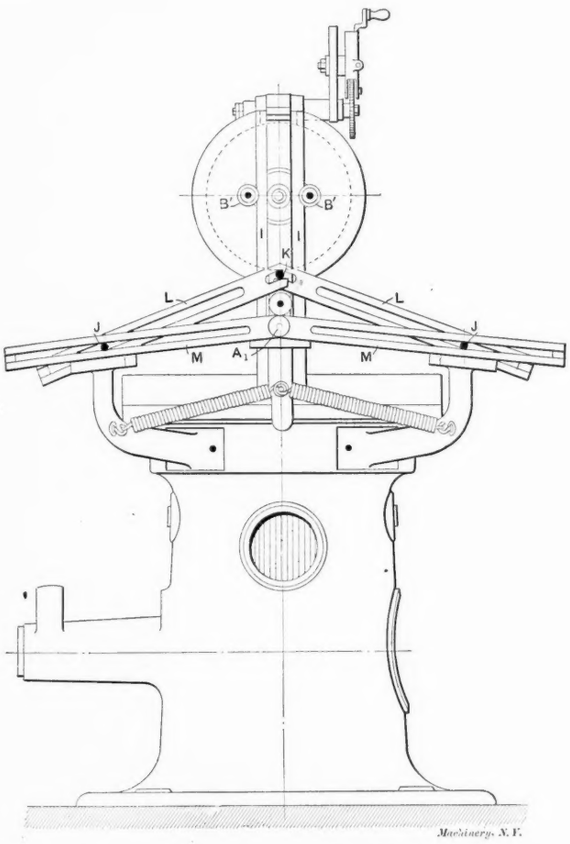


Fig. 8. Diagram showing Arrangement of Approximating Linkage.

of point A_1, to show the construction of links L. Considering however, that the mechanism is in its proper condition, when the blank is given its rotation about vertical axis X X, point K_1, if the proper rolling motion is given the blank, will trace a spherical cycloidal identical with K_1, K_2, K_3 in Fig. 3. To insure that point K shall follow with great exactness this cycloid, as the blank rolls to the left one of the pair of springs shown at the lower end of link I presses pivot K to the bottom of the open ended slot in link L, which is pivoted at point J, this point being selected in the same manner as point J in Fig. 3. It will thus be readily understood that the rotary and rolling motions required for the blank are very closely approximated. Of course the cut is not started from the middle as we have been considering. The blank is first swung to the extreme right, for instance, so that it clears the tools. Under those circumstances the pivot K will bear on the bottom of the open ended slot in the right-hand link L, being held there by the pressure of the right-hand spring. When it reaches the central position shown in Fig. 8 it will be under the restraining influence of both links L. As it continues to swing toward the left it will come under the control of left-hand link L and the left-hand spring.

The various cuts show quite clearly the adjustment required for gears of various pitch cone angles. Sector F is adjustable in a vertical plane about pitch cone apex O on its semi-circular bracket or support, which is integral with table G. This sector F carries the bearing for the blank. The entire indexing mechanism, together with the blank, is of course rotated with link I under the action of links L. The machine is semi-automatic, the indexing being done by hand through means clearly shown in the cuts. Before altering the adjustment of links L for a new pitch cone angle, the table G is first brought to the central position shown in Fig. 8. Pin A_1, shown as A' in Fig. 6, is inserted in a hole in pivot K. Nuts B' on the dividing wheel casing, through which motion is transmitted from links I to the blank, are then loosened. Sector F is adjusted and fastened in its new position on circular bracket G, and nuts B' are tightened in their new positions to correspond with the new angular setting of the head. Pivots J J are now shifted along the slots in guide bars M M to agree with graduations corresponding with the angle to which the blank-carrying spindle is set. After the pivots are tightened in their new locations, pin A_1 is withdrawn and the mechanism is ready for the gear of the new angle.

It is interesting to compare this machine with the Bilgram and Gleason bevel gear generators, both of which operate on the same principle. None of these three machines, however, bear the slightest resemblance to the others externally—an indication of the different ways in which the minds of different designers will act when the same problem is presented to each of them.

* * *

WE HAVE A NEW MAN IN OUR SHOP.

A. P. PRESS.

We had a new man come in last week. You see it is like this: Ours is a country shop, and it is hard work to get a good man; this fellow came along in the office and asked for a job, and said if the boss could stand for his coming in at 8:00 A. M. every morning he would like to go to work. He said it was not convenient for him to get in at 7:00.

Now lots of men come in on the train about 7:15, so the "Boss" said it would be all right, and the next morning at 7:55 in he came. He had a good kit of tools, knew how to use them, and was a good "all-round" man. He turned off more work that first day than I ever saw a new man do before. He had better clothes on than I had when I got married, but he took a clean pair of overalls out of his box, rolled up his sleeves, and showed he wasn't afraid of dirt.

I got to talking with him the first noon, and I found he knew things. One of the first jobs he had to do was to turn up a big, round brass ball about 6 inches diameter—a model of something or other, I think—and I thought he would be stuck. But, not a bit of it; he just put a piece of 2 x 6-inch plank on the faceplate, turned out a place in it that fitted the ball snugly, gave it a "chuck in" and then hand-tooled it up.

He had been here a week or two when our observing "Boss" noticed that he went in a certain house every night, and finally asked him if he lived there. "Sure!" he replied. "Well, if you live there, close to the shop, why don't you get in at 7:00 o'clock?" "Why! I told you when I hired out that it was not convenient for me to do so; you see it seems better for my constitution to lie abed until 7:00." Now, he is a big, strong fellow with the constitution of a giant. The "Boss" was wild and he started to "fling it" into him. "Hold up," said the new man. "Haven't I kept my agreement in both the letter and the spirit, and haven't I given you a dollar's worth of goods for every hundred cents I received? If you want to cancel that agreement, there is a first-class chance for you to do so, right now."

The "Boss" stopped right there and then, and so far the fellow has been coming in at 7:55 just the same, but whether he is a union man and is trying to make this a nine-hour shop, or whether he is plain lazy and doesn't want to work that other hour, we haven't made up our minds yet, but when we have, we will let you know.

DRILL JIGS.—3.

E R. MARKHAM.

Form of the Jig.—The shape and style of the jig must depend on the character of the work, the number of pieces to be drilled, and the degree of accuracy essential. It may be that a simple slab jig of the design shown in Fig. 20 will answer the purpose; if so, it would be folly to make a more expensive tool. If we are to drill a piece of work of the design shown to the left in Fig. 21 and but one hole is to be drilled in each piece, then a jig made in the form of an angle iron, as shown to the right in Fig. 21, works nicely, and is cheaply made. As it is not necessary to move the jig around on the drill press table it may, after locating exactly, be securely fastened to the table. In designing such a jig, it is advisable, when possible, to have the work on the side of the upright shown in Fig. 21, rather than on the opposite side, as we do away with any tendency of the jig to tip when pressure is applied in the operation of drilling.

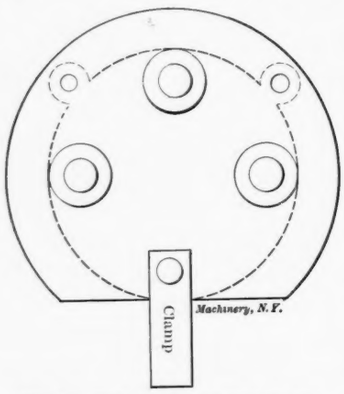


Fig. 20. Slab Jig of Simplest Design.

For many kinds of work a jig provided with a leaf, as shown in Fig. 22, gives best results, as the leaf may be raised, and the work removed, and any dirt cleaned from the working surfaces. After placing the piece to be drilled in the jig, the leaf is closed. As the bushings are in the leaf, it is apparent that it must always occupy the same relative position to the work for the different pieces, or they will not be duplicates; consequently the fulcrum pin, *a*, must be a perfect fit in the hole in the leaf, and a locating pin *b* is provided to prevent any tendency of the leaf to move from the action of the drill when cutting. Jigs provided with such a pin show less tendency to wear in the joint. The leaf should not close down onto the work, but onto a shoulder on pin *b* as shown, there being a space between the work and the jig leaf.

While the above is true for most work, a jig for drilling round pieces may be designed as shown in Fig. 23, the holding device being two V-shaped blocks, one located on the lower

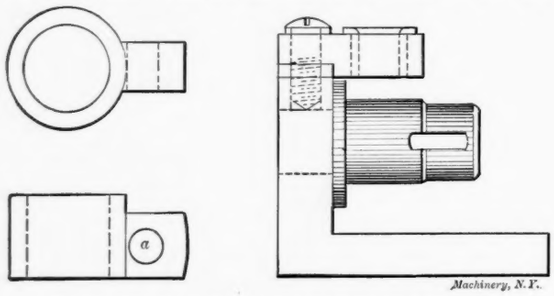


Fig. 21. Piece to be Drilled and Jig Used for this Work.

portion of the jig, while the other is on the leaf, as shown. In the case of a jig of this pattern the work is securely held by binding the cylindrical piece by pressing the handles of the jig together.

When jigs are to be moved around on the table of the drill press as is the case where several holes are to be drilled, legs are generally provided, as shown in Fig. 22. In order that the legs may not wear it is customary to harden them. The legs are hardened before they are placed in the jig, and are ground and lapped true while in the jig. As the only wear is on the ends, or where they come in contact with the drill press table, it is customary to harden only the ends which rest on the table. In most shops jig legs are made from tool steel, although a good grade of open-hearth steel containing sufficient carbon to insure its hardening answers as well for most purposes. But as few shops carry such steel in stock, crucible tool steel is generally used. The ends of the legs should be ground true with the seating surface—that is, where the work rests—of the jig. To accomplish this a surface grinder should be used. As the operation of grinding leaves a number of projections on the surface ground, and as these ridges or projections would wear away as the legs were moved back and forth on the drill press table, it is advisable to remove them by lapping on a flat lap, thus producing a perfectly smooth, true surface. In this way we reduce the wear to the minimum.

For certain classes of jigs the legs may be short, not more than ½ inch long; but for jigs of the style shown in Fig. 22, where the tool is held in the hand, it is necessary to make the legs longer to keep the fingers from coming in contact with the chips on the drill press table. The legs should be located so as to do away with any tendency of the jig to tip up when the work is being drilled.

While it is necessary to observe extreme care in designing drill jigs to prevent any tendency of the jig to tip, and to have the legs ground and lapped on a true plane, it is just as necessary that the drill press table should be perfectly at right angles to the spindle, and that it should be true and flat. Otherwise the holes will not be at the desired angle with the working surface of the work.

In shops where interchangeable work is produced, or where the work must in all respects be machined correctly, the con-

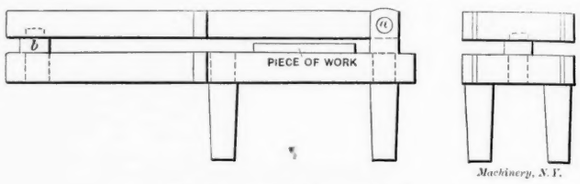


Fig. 22. Jig with Pivoted Leaf.

dition of the various machines is closely watched, and especially such parts of the machines as affect the accuracy of the finished product. Drill press tables are planed over when out of true, or are lined up to insure their being at right angles to the spindles of the drill press. This may be done by placing a bent wire in the drill chuck, the wire being bent so that it will describe as large a circle as possible, and yet be free to swing. The end of the wire is bent so that a point will come in contact with the table. By loosening the screws holding the table, and inserting "shims," it may be trued as desired.

Locating the Holes for Drill Bushings.—When making jigs, the part of the work that calls for the best workmanship is locating the holes for drill bushings. The methods employed differ, but should depend on the character of the work. Where accuracy is not essential it is the custom many times to take a piece of work that is right, that is, one where the holes are drilled near enough right, place this in the jig and transfer the holes into the jig. As it is necessary to leave the bushing holes in the jig considerably larger than the holes in the work in order to have sufficient stock around the holes in the bushing, those in the jig may be enlarged by means of a counterbore, the pilot of which fits

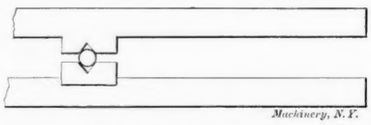


Fig. 23. Part of Jig with Pivoted Leaf, showing Method of Holding Round Work.

nicely in the transferred holes, and with a body the size of the desired hole. When this method would not insure desired accuracy, several other methods may be employed.

If a model of the work to be done is at hand a jig, as shown in Fig. 22, may be made in the following way. The leaf is raised and the model placed in it. The jig is fastened to the faceplate of the lathe, the leaf still being raised. By means of a center indicator the jig is located so that one hole of the model runs true, the leaf is then closed and the hole is drilled through it, and then bored with a boring tool to the desired size. Never ream a bushing hole in a jig, or

any similar hole in any piece of work, where the finished hole must be exactly located, as a reamer is liable to run out somewhat, and thus affect the accuracy of the work. A reamer, if properly made and used, will produce a round, true hole, accurate as to size, and is a valuable tool for many purposes, and holes of a uniform size may be produced. But on account of the stock being uneven in texture, or on account of blow holes in castings, a reamer is liable to alter its course and so change the location of the hole. While for many purposes this slight alteration of location might be of no account, yet for work where accuracy is essential, it is out of the question.

After drilling and boring the first hole the jig may be moved on the faceplate, and the other holes produced. It is obvious that in order to produce holes that will be at right angles to the base of the jig, the faceplate of the lathe must run true, and should be tested each time it is used for any work where accuracy must be observed.

Where there is no model, and it is not considered advisable to make working models of the various parts, the location of the bushing holes may be obtained by laying out the various points on the jig. In such cases a drawing is usually furnished, and the dimensions on same are transferred to the face of the jig. If it is not necessary to have the holes exact as to measurements, the laying out may be done with a

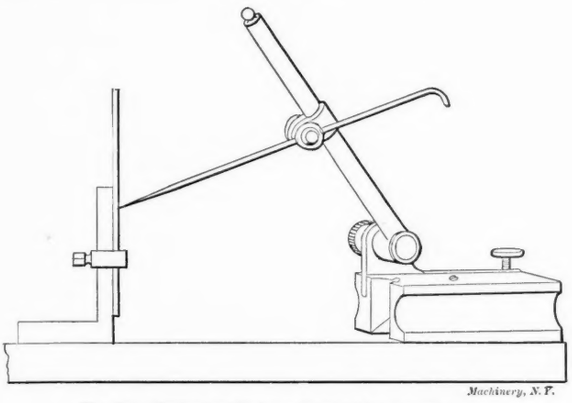


Fig. 24. Method of Taking Vertical Measurements.

surface gage, the point of the needle being set to a scale. The scale may be clamped against an angle iron, as shown in Fig. 24, or an angle iron may have a groove of the width of the scale cut across its face at right angles to the base, as shown in Fig. 25. The scale should be a good fit in the groove, so fitted that it will stay securely at any point from frictional contact with the sides of the slot, or a spring may be located as to insure the proper tension.

Where greater accuracy is essential the working points should be obtained by means of a height gage, as shown in Fig. 26. By means of such a tool the measurements may be fairly accurate, as the Vernier scale allows of readings to one thousandth inch.

When the lines have been scribed at the proper locations they are prick punched. In order to prick punch exactly at the intersection of lines the operator must wear a powerful

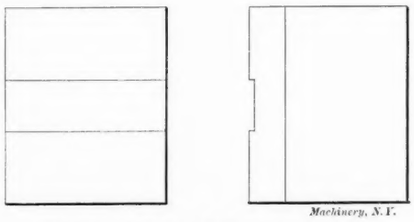


Fig. 25. Angle Iron with Groove for Scale.

eye-glass and use a carefully-pointed punch ground to an angle of 60 degrees. If the punch marks are made very light at first the exact location may be observed nicely. The punch marks should not be deep, as there is a liability of alteration of location if the punch is struck with heavy blows. After the various points have been located and punched the jig may be clamped to the faceplate of the lathe and the bushing holes carefully drilled and bored to size.

At times jigs are made of such size and design that it seems wise to core the bushing holes. In such cases it is necessary, in order that we may lay out the location of the centers of desired holes to press a piece of sheet steel or

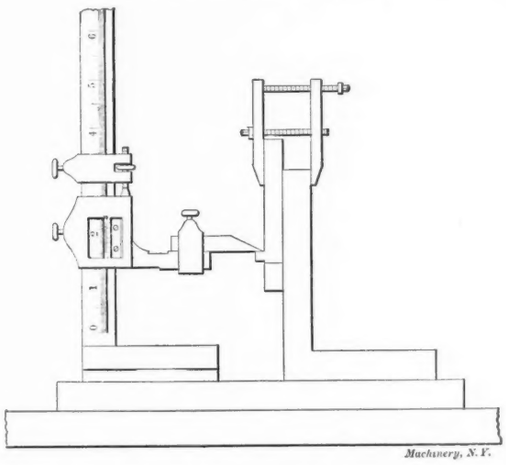


Fig. 26. Taking Vertical Measurements by Means of Height Gage.

sheet brass into the cored hole, as shown in Fig. 27, and locate the center on this piece. When the jig has been properly located for machining, the sheet metal may be removed and the hole machined to desired size. If an error of 0.001 or 0.002 inch is not permissible the method described above will not answer.

Where extreme accuracy is essential we must locate round pieces of steel on the face of our work. These pieces of steel are called buttons and are of exact size and perfectly round. To do away with any possibility of their becoming bruised in any way they are hardened and carefully ground to size. The buttons are attached to the work by means of machine screws, as shown in Fig. 28, the holes in the buttons being larger than the screws used; this difference in size allows us to move the button until it is accurately located. The diameter of the buttons should be some standard size,

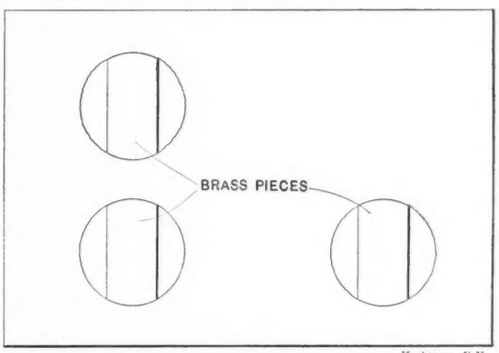


Fig. 27. Cored Holes with Inserted Brass Pieces for Centers.

easily divisible by two, because, in making our computations we only consider the distance from the center of the button to its circumference, that is, the radius.

When we start to lay out the centers for the bushing holes we first determine our working surface, then lay out on the face of the jig, by means of a surface gage, as described in a previous operation, the centers of the holes to be produced. We then drill and tap screw holes to receive the screws to be used in holding the buttons to the jig. When we have prick-punched the surface and before drilling the holes we scribe by means of dividers a circle of the size of the button on the face of the jig with the punch mark as center. This enables us to approximately locate the button. If the hole to be produced has its center 2 inches from the base *a* and 4 inches from vertical side *b*, Fig. 29, we would locate the button—provided it was ½ inch diameter—1¾ inches from *a*, and 3¾ inches from *b*. This can be done accurately by use

of a Vernier caliper, or we can lay the jig on the side *b*, and by means of a length gage, or a piece of wire filed to the right length, accurately determine the distance from *b* to the button. The jig is then placed on the base *a* and the other dimension obtained in the same manner. The buttons may be located more easily by the use of a Vernier height gage, if one is at hand.

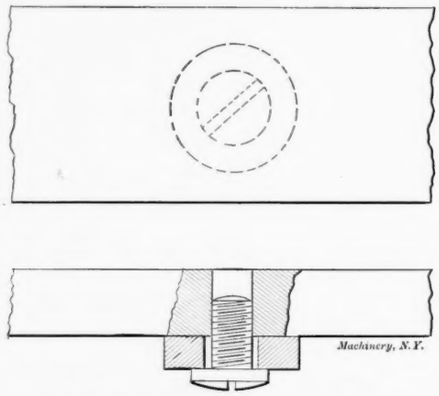


Fig. 28. Buttons for Locating Holes in Jigs.

If there are to be several bushings on the face of a jig a button may be accurately located where each hole is to be. The jig may be clamped to the faceplate of the lathe so that one button is located to run exactly true. This is done by means of a lathe indicator. When the jig has been so located that the button runs perfectly true, the button may be removed and the hole enlarged by means of a drill so that a boring tool can be used to bore it to the proper diameter.

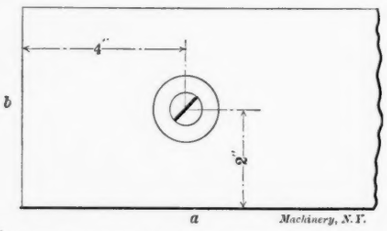


Fig. 29. Locating a Hole by Means of a Button.

In some shops it is not considered advisable to locate a button at the desired position of each bushing hole. One button is located and the jig is fastened to the table of a milling machine having a corrected screw for each adjustment. Then, after one hole is accurately located and bored, it is a comparatively easy matter, by means of graduated dials, to obtain the other locations; however, this method should never be used unless the machine has all its movements governed by "corrected" screws, as the screws ordinarily sent out on milling machines are not correct as to pitch, and if used serious defects in measurement will result.

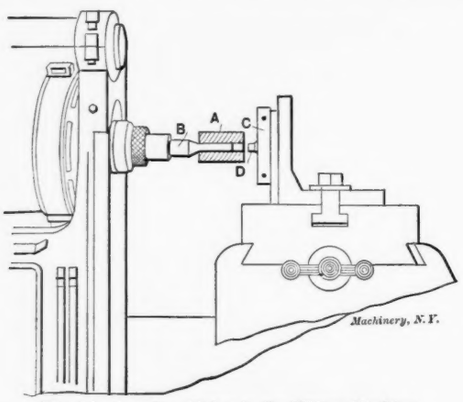


Fig. 30. Locating Holes in the Milling Machine.

Fig. 30 shows a jig clamped to an angle iron on the table of the milling machine. The angle iron is located exactly in line with the travel of the table, and the jig fastened to it. The button *D* which has previously been accurately located serves as a starting point, and the jig must be located so that the button is exactly in line with the spindle of the machine. This is accomplished by moving the table until the sleeve *A* on the arbor *B* will just slide over the button *D*. The hole in *A* must be a nice sliding fit on the arbor *B* and also on the button *D*. In order to insure accuracy, the arbor *B* must be turned to size in the spindle just as it is to be used, or, if a portable grinder is at hand the arbor may be fitted to the spindle hole or to the collet, as the case may be, the portion which receives the sleeve *A* may be left a trifle large and ground to size in place in the machine. The portable grinder is located on the table of the machine.

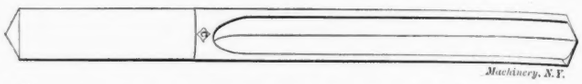


Fig. 31. Straight-fluted Drill for Jig Work.

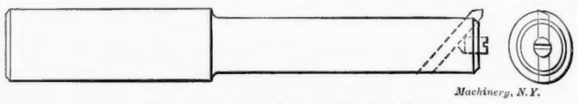


Fig. 32. Inserted Cutter Boring Tool.

After the jig has been accurately located so that the button *D* allows the sleeve *A* to slide over it, the arbor *B* may be removed from the spindle, and a drill be employed to increase the size of the tapped screw hole that received the screw used in fastening the button. Best results follow if a straight-fluted drill, as shown in Fig. 31, is used. The drill should not project from the chuck or collet any further than necessary, thus insuring the greatest rigidity possible. After drilling, a boring tool of the form shown in Fig. 32 may be substituted for the drill and the hole bored to size. The machine may now be moved to position for the next bushing hole by observing the dimensions given. The operator should bear in mind that the screw used in getting the spacings must be turned in the same direction at all times, otherwise the backlash will render accuracy out of the question.

While the foregoing relates to plain jigs the same principles apply to those of more complicated design.

* * *

How many readers of MACHINERY have ever noticed that a boiler plate sheet when formed into the shape of a boiler shell does not bend on its center line or nominal neutral axis? A boilermaker always takes the measure of the straight sheet for a certain outside girth, and makes little or no allowance for change of length due to bending. When a sheet is in the bending rolls it may be noted that practically all the scale cracks loose from the interior of the shell and very little drops off from the exterior. The fact that there is little or no change in length of the outside fibers indicates that the inner fibers are compressed and that the sheet as a whole is thickened slightly, and this is what actually takes place. It is somewhat difficult to understand why this peculiar action takes place until it is remembered that bending a bar of, say, approximately square section, narrows its exterior width and thickens the interior width inasmuch as it then bends on its neutral axis or center line, but the great width of the boiler sheet as compared with its thickness precludes the possibility of the sheet narrowing throughout its width in order to compensate for the stretching exterior fibers, the consequence being that the sheet does not change its cross section materially in shape beyond thickening it a slight amount as just indicated. Hence the exterior fibers are not changed in length, but the inner ones are shortened.

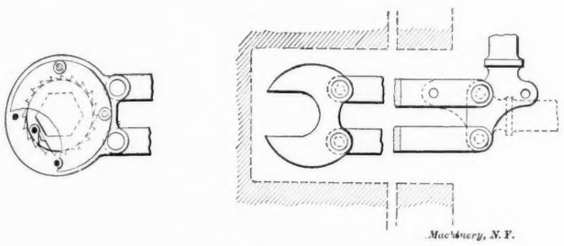
* * *

The great gulf that often exists between the theorist and the practical man is very well illustrated by an incident mentioned in the *Valve World*. It says that Lord Kelvin, the famous English scientist, once paid a visit to the schoolship for navigation officers at Portsmouth, England. On board there were several mechanical appliances of his own invention, but the workings had to be explained to him. He understood the theoretical principles of the mechanism, but had never seen them applied at work before and could not readily comprehend them when embodied in metal.

ITEMS OF MECHANICAL INTEREST.

A WRENCH FOR CONFINED SPACES.

The device shown in the cut will enable a workman to turn a nut or tap screw at the extreme end of a radial pocket of great length and small dimensions. It may be made, as shown, either as a ratchet wrench or as a solid jaw wrench, the part that engages the head of the nut in either case being rotated through a short arc of action by the two links, which are operated by the bell crank and handle at the outer end.

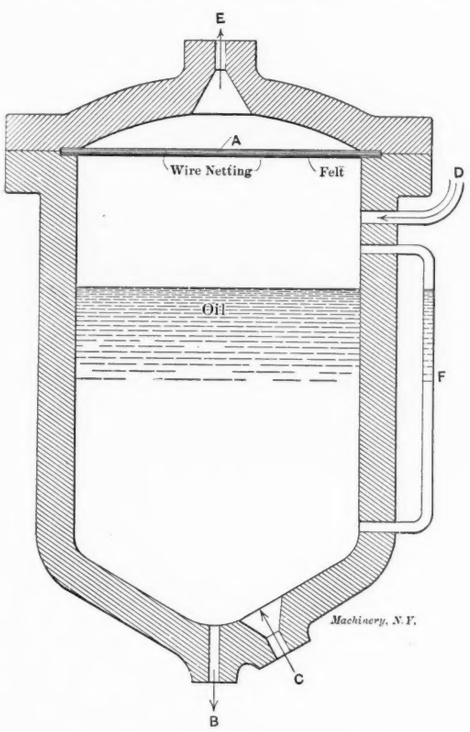


A Wrench for Confined Spaces.

This bell crank and its attached handle may be given either of two positions, as shown in the cut; the full lines indicate a position at right angles to the vibrating links, while the dotted lines show an alternative arrangement obtained by shifting one of the pivot pins. The choice of these two positions is determined by the amount of room available for swinging the handle. The idea has been patented in England and Germany.

SEPARATOR FOR WATER IN COMPRESSED AIR.

As is well-known, atmospheric air contains a certain amount of water and its capacity for water increases with the temperature of the air. When compressed, this water is carried with the air through the pipes to places where the air is to be used, and as the air is often cooled off to a great extent during its passage through long pipe lines the water has a tendency to condense in a greater or less degree. When used in manufacturing establishments, for auto-pneumatic machinery, as has of late become more and more common, the condensed water following the air often causes troubles. When the machines are shut down the water is collecting and will cause rusting of the parts with consequent difficulty of starting the machine and making the pistons and valves move freely. To overcome the troubles thus met with, and in order to separate the condensed water from the air, a simple arrangement may be adopted. A cast iron receiver in the form of a cylinder, as shown in the cut, and provided with a cover, is nearly filled with oil, and air is caused to pass through the oil before passing into the machine. The condensed water will then stay with the oil, while the air will proceed through a filter, a shown in the cut at *A*. As the specific gravity of water is greater than that of oil, the water will evidently collect at the bottom of the receiver and can be let out whenever a sufficient amount is collected. In the cut the outlet for the water is shown at *B*, the main air supply at *C*, the pipe for the oil supply at *D*, and the outlet of the air to the machines at *E*. The oil is of course replaced only when the volume is diminished to a considerable degree owing to some particles of oil escaping at the time when the water is let out. An ordinary water gage, as indicated at *F* may be used to indicate the height of the oil or the amount of oil and water in the receiver. The felt filter is held in place between two sheets of fine wire netting which are fastened in small recesses, one to the cover and one to the receiver itself.

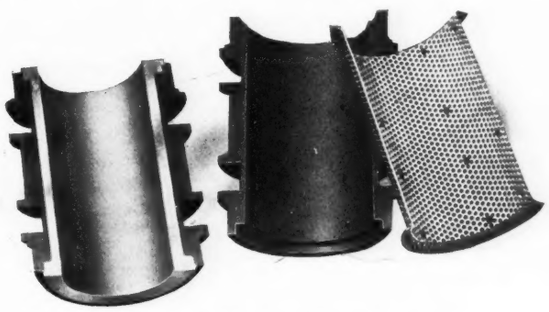


Separator for Water in Compressed Air.

There may be a question about whether the oil plays any important role in the separation of the condensed water from the air, inasmuch as it is very likely that if the air containing condensed particles of water were simply discharged into the large receiver, the water would probably collect just the same. Where the writer has seen this receiver used it is always used with oil, but it would be of interest if experiments could be made to ascertain whether the oil is an essential part or not.

THE "GLYCO" SKELETON LINING FOR BEARINGS.

The accompanying cut shows an unusual and interesting way of securing the babbitt to a cast iron bearing. A tinned sheet iron lining is perforated and screwed onto the cast iron body of the bearing. The screws are provided with wood screw heads, and the holes in the cast iron body are countersunk so that the screws can bend the thin sheet metal downward around the head, and wedge it in between the head and the cast iron, thus holding the lining in place very securely. The babbitt is then poured on the tinned lining and fuses with it to a solid mass. The babbitt also fills all the small perforations and in doing so not only gets a very firm support on the cast iron below the lining, but will be still more firmly held in place than by the fusion of the metals alone, somewhat in a similar way as plaster is secured to the walls of a building. The advantages which are claimed for this way of making a bearing, which has its origin in Germany, are that the babbitt is held in place even more securely than if the cast iron body of the bearing were provided with dove-tail slots; the babbitt lining of the bearing can be thinner on account of the uniform way in which it is held to the body; the cast iron body itself can be made thinner, not being provided with grooves of any kind which impair its strength. This, of course, would decrease the cost of castings in cases of production on a large scale. The linings themselves can be produced very cheaply if made in quantities. They are known as the Glyco skeleton linings for bearings, and are manufactured by the Glyco Metall Gesellschaft, G. m. b. H., Wiesbaden, Germany.



The "Glyco" Skeleton Lining for Bearings.

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Entered at the Post-Office in New York City as Second-Class Mail Matter.

MACHINERY

REGISTERED IN UNITED STATES PATENT OFFICE.

DESIGN—CONSTRUCTION—OPERATION.

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS,

66-70 WEST BROADWAY, NEW YORK CITY.

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We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

JANUARY, 1907.

PAID CIRCULATION FOR DECEMBER, 1906,—22,497 COPIES.

MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages. The Engineering Edition—$2.00 a year—contains all the matter in the Shop Edition and about 250 pages a year of additional matter, which includes a review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. RAILWAY MACHINERY, $2.00 a year, is a special edition, including a variety of matter for railway shop work—same size as Engineering and same number of data sheets.

ONE THING AT A TIME.

There is one point that stands out clearly in the remarkable paper "On the Art of Cutting Metals," presented as his presidential address by Mr. Fred. W. Taylor, at the December meeting of the American Society of Mechanical Engineers, and that is the wisdom and practical necessity of determining one factor at a time if experimental work shall produce results having any clear-cut significance and value. In the course of Mr. Taylor's and his associates' herculean investigations of the laws governing the action of cutting tools, it was found that no less than twelve distinct and independent variables affect the production of chips. To develop formulas which would enable the task foreman to set the speed and feed of a machine it was necessary to know the value of each and every one of these independent variables, and then it was possible to construct a slide rule for the machine. It was of little conclusive value to learn what was the effect of two or more factors at once for then there could be no accurate deduction as to the actual part played by each. It took a long time to learn this simple truth, but it had to be recognized before results were obtained which could be analyzed and profitably used.

As to the ultimate result of this remarkable investigation into the laws of cutting metals now for the first time published, it almost staggers the mind to comprehend, for if we are not greatly mistaken, it and the parallel work in improving shop management will mean a great change in manufacturing, not only in the metal-working industries, but in all branches of manufacturing as well, and this means that some of the present economic ideas may be turned upside down. But on the principle of minding only one thing at a time we shall not worry about that, but shall attend to the present business of trying to comprehend the practical significance of Mr. Taylor's paper and of keeping abreast of the impulsive progress that should result from its publication.

* * *

SPECIFIC TRADE KNOWLEDGE SOMETIMES A DETRIMENT.

There are few trades but which have so-called trade secrets; some of these secrets are considered important if not absolutely vital to the success of the business, while the value of others is largely fictitious and is held up more for effect than for any real merit. The natural impulse for any one who would start to manufacture some product requiring considerable special and expert knowledge and skill would be to learn all he possibly could about the state of the art beforehand and then adopt the best in his practice. Theoretically this should be the right thing to do, but sometimes he might be better off to know less about the state of an art and thus avoid imitating and using bad practice—in short, to follow his ideals rather than present practice. The practitioners of almost any art know a whole lot of things that are not so. They are naturally conservative and have great reverence for certain forms and features of their work which a beginner, not imbued with the same ideas, would entirely avoid. In short, the gist of the foregoing is that if a new business is to be started it may be better to cut loose entirely from the prejudices and practice of the trade and branch out on entirely new lines, starting with a clean sheet and employing only men who have good intelligence but no preconceived ideas as to this business. No doubt many mistakes would be made at first and more capital probably would be required in the start to make the business a success, but the chance of success is greater, we believe, than it would be to act as a mere imitator and not as a pioneer in improving the art.

Take for example the practice of making any small tool or machine part. Suppose we take the business of making chucks. The older shops which have been engaged in chuck making for many years have many special tools and appliances which they naturally believe are very essential to the success of their business, but no doubt it would be possible to start in business of making chucks, using only modern machine tools with few exceptions perhaps, and be able to compete successfully so far as manufacturing cost is concerned with any of the present chuck makers. The great disadvantage to which a new firm is subject in any business is lack of established market for its goods, and this disadvantage may easily outweigh any advantage due to new manufacturing methods. No doubt established markets keep many old concerns from bankruptcy long after it should logically appear.

* * *

THE IMPORTANCE OF INDUSTRIAL EDUCATION

In his message to the second session of the 59th Congress, President Roosevelt voices the general interest in industrial education. He deprecates the present system of public school education to train boys and girls in literary accomplishments to the total exclusion of industrial, manual and technical training; and recognizes that our future industrial development depends very largely upon technical education including in this term all industrial education—not only that which fits a man to be a good mechanic, carpenter, or blacksmith, but that which fits him to be a great engineer as well. The training of one class is as necessary as the other and the nation's prosperity depends as much on the manual training as on engineering training.

The recent organization of the National Society for the Promotion of Industrial Education is a movement of considerable importance along this line, but we fear that unless the promoters are unusually broad-minded the movement is likely to lose much of its force in becoming confused with a general scheme of education. The professional educator's idea of education is not in general of a very practical nature. He was brought up in an atmosphere quite apart from that which surrounds the workman who earns his daily bread by the toil of his hands, consequently very few educators, so-called, fully understand the present need of industrial education.

The excellent paper by Mr. Dean which appears on another page of this issue points out some of the needs of evening schools which would meet the requirements of industrial workers who are employed through the day. He points out very clearly the need of practical education which shall from the start meet the wants of these workers and give them that which will help them to earn more money and become more efficient workmen. This is something to the point.

We must all recognize the fact that our present industrial system does not provide for the education of young mechanics who will by the natural process of selection become fitted for responsible positions in the future. So far as efficiency of production is concerned the system of making each workman a specialist is inevitable, but along with other evils it has the great lack of not providing men having a wide embracing knowledge of their trade which shall enable them to act as foremen and superintendents of the same work.

THE COST ACCOUNT AND THE DRAWING ROOM.

There are probably very few draftsmen who have not, at some time or other, experienced that cooling effect on their enthusiasm which follows when the superintendent or the manager, after having looked over a new design, in one's own estimation particularly ingenious, pronounces it as "all right, but too expensive to build."

It is evident that the superintendent thinks that the draftsman has no idea of the cost of building the devices he designs. This may be true to a certain extent, but if a critical view is taken of the question, the draftsman is perhaps the one least to blame for this unfortunate condition.

The cost department in most of our large establishments is conducted, one might say, on a purely confidential basis. The cost of the tools or devices made, the cost of the manufactured product, and the margin of profit is considered as a secret not concerning anybody but the higher officials of the concern. While this may be a perfectly proper attitude from a certain point of view, it places the men who are supposed to design the new devices by which the production is to be increased, and the cost decreased, in a very difficult and undesirable position.

The designer or draftsman who is called upon to perfect the method for doing a certain operation will evidently try to devise a scheme as nearly perfect as his ability permits. The device or the machine which is the result of his work may be a very costly one, but it may cut down the cost of production so materially as to be a cheap improvement when used for a sufficiently long time. However, it may be that the device is to be used for the manufacture of a certain article which is not sold in any great quantities, nor at any considerable margin of profit. In such a case, the new proposition may be one extremely costly. But the draftsman cannot be expected to judge as to the relative cost of the design, unless he is permitted to inform himself upon the questions determining the advisability of going into great expenses. This is, however, in many cases denied him, and when he is sufficiently interested in the success of the work assigned to him to try to find out for himself, it is not unusual that he is made to understand that the business of the cost department is not within his territory.

The result, of course, is that the designer puts his best efforts in perfecting a device which is afterward to be pronounced as too expensive. It is, however, poor policy to determine upon the cost of a device after it is designed. It would be far better if the designer, before starting to put his ideas on paper, were given the opportunity to form a clear conception of the commercial results to be accomplished. This can be done only by permitting him to find out to what expense he may consistently go in his design, and this expense depends primarily upon all the little facts of present cost and margin of profit and the amount sold of the article produced.

By opening the way to such information to the designer, a great amount of uselessly spent energy could be used for better purposes. Knowing that the saving on a certain operation in the shop could be but a trifle, no matter how perfect the tools used might be, no time would be wasted on the invention of costly machines for the performance of such an operation. But on the other hand, in a case where the saving would be very considerable, and the production of the article so great that a very expensive device would be warranted, provided it were efficient, in such a case the designer would know that here was an opportunity for him to let the whole of his ingenuity come to the front. He would not feel deterred from doing his best, fearing that he would turn out something "too expensive."

While it would be indicative of poor business judgment to advocate that the accounts of the cost department should be open to whosoever wished to pry into its secrets, it may not be an uncalled for suggestion to point out that better results could in many cases be obtained, if such men, upon whom the development of the paying qualities of the shop largely depend, were not denied such information as would materially help them to satisfactorily solve the problems of decreasing the cost of production.

THE SECOND-CLASS POSTAL RATE AGITATION.

The present agitation by the United States post-office officials to increase the second-class postage rate which now applies to periodicals has brought forth a remarkable proposal from Mr. W. D. Boyce of Chicago. It cannot be supposed that the proposal is made with the expectation of its being accepted, and it must, therefore, be regarded largely in the nature of a gigantic "bluff," but nevertheless it is of interest, especially at this time, when the second-class rate is being so warmly discussed. Mr. Boyce proposes that the United States government turn the post-office business over to a $50,000,000 private corporation under full government regulation. In return he promises to reduce all postal rates one-half; to establish rural postal express; to pay full rental into the government treasury for all post-office quarters; to charge the government regular rates for its postal business; and to turn over to the government all profits above 7 per cent of capital invested. Mr. Boyce is a Chicago publisher and supposedly has intimate knowledge of the conditions of post-office working and of the enormous business due to second-class mail matter.

To effect this undertaking he would, in the first place, cut out all sinecures, which means that the political postmaster who draws a big salary and pays a deputy for attending to his work would get short shrift. The most important feature of the plan outlined, however, is putting the business on an equitable basis as to railway transportation. The business would first of all be put in charge of a railroad traffic manager, and some of the large juicy plums now going to certain railways for transportation for postal matter would be cut off. He estimates that the expenditure for railroad haulage could be cut down from $50,000,000 annually to about one-half that sum. It is also pointed out that one reason for the present inefficiency of postal management is that nine different postmaster-generals have occupied the position during twenty years. This of course is in keeping with our absurd system of political rotation in office, which formerly obtained in all grades of government employ, but it is not in keeping with good business methods. We can scarcely conceive of any successful business man who would change his general manager on an average of once in two years. A business that could succeed in spite of such adverse conditions must be something of the nature of a natural monopoly or one in which the management cut very little figure.

Most opponents of an increase of rate on second-class matter recognize the presumable fact that under *present* conditions the carrying of this class is done at a loss, but to offset this there is no question but that the carrying of second class matter is responsible for an enormous number of letters in direct response to advertising or other features incident to the business of a publication. All letters, of course, are subject to the first-class rate and this is highly profitable. It is a moot question whether the government would not lose largely by extinguishing a large quantity of second-class publications (as would undoubtedly result with a large increase in postal rate), because of the loss of first-class postal matter.

The present agitation may happily result in the reorganization of our postal system on sound economic principles and the elimination of useless expense and leaks which now no doubt are fully as much responsible for the present enormous annual deficit of something like $7,000,000 or $8,000,000 yearly as the so-called second-class privilege which is extended to publishers only.

* * *

A man, like a battleship, is supported by his own displacement; and, if he is to hold his own in the battle of life, with freeboard enough for winter weather, he must have a high box coefficient. His only foundation on the sea of life is his power of displacement. A man, when launched into the world, finds no empty place made ready to receive him. No one scoops out a hole in the water to receive the ship; when launched she must displace her weight of the element into which she plunges. So a man displaces his weight of whatever element is opposed to him.—*Extract from paper, "The Man and the Ship," read by Mr. George W. Dickie before the Technical Society of the Pacific Coast, March* 3, 1905.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

It is stated in the *Times Engineering Supplement* that deposits of vanadium have been found in Peru. A syndicate of Pittsburg capitalists is reported to have obtained a concession from the Peruvian government for working the deposits.

According to the *Practical Engineer* the best efficiency in turbines is obtained by using Francis turbines for heads not considerably exceeding 300 feet, and Pelton wheels for heads between 175 and 1,600 feet.

An indication of what may become the common attitude of large cities as to steam locomotives is that of the District of Columbia. The commissioners of the district have announced that when the new Union Station is completed no steam locomotives will be allowed on any of the railroads within the city limits. All locomotives drawing trains must, therefore, be electric, compressed air, or some type in which there is no obnoxious combustion of fuel.

Last November the new Japanese battleship *Satsuma* was successfully launched from the Yokosuka Dockyard. This vessel, which is the only one afloat comparable with the English *Dreadnaught* has been designed and constructed exclusively by Japanese engineers. The armorplate, as well as the guns, have been produced in Japan, and in fact the Japanese have demonstrated to the world that they have become entirely independent of the Western hemisphere even in the field of highly specialized engineering. The vessel has a displacement of 19,200 tons.

In the operation of air compressors the best results are obtained, it is said, when the areas of the suction and discharge valves are equal and of such proportions that the velocity of the air does not exceed 5,500 feet per minute. On a compressor run with a piston speed of 550 feet per minute, this requires a valve area equal to 10 per cent of the piston area. The practice of making suction valve areas larger than those of the discharge valves is not advised as, while the incoming air is of greater volume, the discharge valves remain open for a very small proportion of the stroke.—*Engineering Record.*

The McKeesport plant of the National Tube Co. are now making and shipping pipe in 40-foot lengths. The use of long pipe is desirable, of course, on account of reducing the number of joints and the liability of leakage; the less number of joints also materially reduces the labor of installation. For these reasons the long lengths of pipes are being used in extensive pipe installations such as refrigerator plants, pneumatic and hydraulic pipe lines, etc. The 40-foot pipe is made in 1 to 3-inch sizes, standard and extra strength, but as yet no galvanized pipe of this length is made.

In an address on large gas engines at the Engineering and Machinery Exhibition at London, Mr. H. A. Humphrey stated that under favorable working conditions a large gas engine may develop a horsepower hour for 0.8 pound of coal, while a steam engine would require two pounds to develop the same power. He also said that he had information to the effect that the use of gas engines in rolling mills had reduced the cost of the finished product about $3.00 to $4.50 per ton. The large gas engine has had great success on the European Continent where coal is more expensive than in England and the United States.

According to *Chambers' Journal* the Niagara Electro Chemical Co. has recently introduced a new product named oxone. This is made from a specially prepared form of sodium peroxide. Its value lies in its power of giving out free oxygen in the presence of carbonic acid gas and water. By this means air in confined spaces may be kept furnished and supplied with oxygen for breathing purposes for an indefinite period provided, of course, that the carbon dioxide is absorbed in the process. This product promises to be of great service in mining, as miners equipped with oxone will be able to go into drives or slopes without the present evil effects. It also should be greatly serviceable in submarine boats.

Tests made (in 1904, continuing to 1906) by Messrs. Howe and Harrington at the Worcester Polytechnic Institute, to determine the specific heat of fire-brick gave, as might be expected, varying specific heats in the temperature range 0 to 1,100 degrees C. (32 to 2,012 degrees F.) From 0 to 100 degrees C. (32 to 212 degrees F.) the specific heat was 0.221; from 500 to 600 degrees C. (932 to 1,112 degrees F.) it was 0.251; and from 1,000 to 1,100 degrees C. (1,832 to 2,012 degrees F.) 0.281. Only one kind of fire-brick was tested, but it is not thought probable that other kinds will differ widely in their specific heats. The precise determination of the specific heat of fire-brick is of value in figuring the heat absorptive value of boiler settings, etc.

The cohesion and tenacity of concrete structures has been amply demonstrated in a case of a building of reinforced concrete in Tunis, Africa. The building itself is five stories high and is constructed entirely of reinforced concrete. When nearly completed the foundation on one side settled to such an extent that the building slowly sunk on this side until the walls formed an angle of 25 degrees with the vertical line. By excavating the foundation and counterloading the floors on the opposite side of the building it was restored to a level position without any injury whatever to the structure itself. The possibility of doing this proves the presence of qualities of enormous endurance in buildings of reinforced concrete, presenting as they do a single solid structural unit.

We have of late referred several times to the possibilities for windmills, but have not called attention to the fact that there are at present windmills designed in rather large units. According to *Power*, one mill developing 50 horsepower was erected as an experiment in Golden Gate Park, San Francisco, for pumping water. This windmill fulfilled all expectations so well and proved so economical that another is being built. It is claimed that several thousand dollars per year are saved by this windmill, comparing the expense with that of other motive power. Apart from the pumping machinery, such a mill can be built for less than $1,500. In Holland windmills 50 feet in diameter and developing from 40 to 60 horsepower in good wind are not unusual, and are used not only for pumping purposes but for driving grist-mills, sawmills, and many other kinds of small industrial plants.

The following empirical rules are suggested by Mr. Dugald Clerk for approximating the power of gas engines. For engines not exceeding 12 H. P.:

$$\text{H. P.} = \frac{D^2 \times N}{3}$$

and for engines exceeding 12 H. P.:

$$\text{H. P.} = \frac{D^2 \times N}{2.4}$$

in which

D = diameter of cylinders, in inches.

N = number of cylinders.

These formulas are based on the assumption that an average of about 70 pounds mean effective pressure and a piston speed of 800 feet apply to engines not exceeding 12 H. P.; and 70 pounds mean effective pressure and 1,000 feet to engines exceeding 12 H. P.

The longest concrete arch yet undertaken anywhere is that of the main span of the Walnut Lane bridge in Philadelphia. Not only is it the largest of its class, but it has the third place in the list of long-span arches of all classes of masonry, so that the structure must be regarded as one of the most

interesting engineering undertakings of to-day. The longest masonry bridge in the world is the structure at Plauen, Saxony; it has a clear span of 295.2 feet. The second place is held by the bridge over the Petrusse River in Luxemburg; it has a span of 275.5 feet and a rise of 101.8 feet. The third place is held by the Walnut Lane span of 233 feet. The fourth place is occupied by the Gruenwald bridge over the Isar River at Munich, which has a reinforced concrete span of 230 feet and a rise of 42 feet. The famous Cabin John bridge near Washington has now dropped back to fifth place. It is not at all improbable, however, that this list will see some important additions before many years have elapsed, for the construction of longspan reinforced concrete arches has not yet begun. The 230 feet of the Gruenwald bridge, the longest concrete structure with metal reinforcement, is of insignificant length when measured by the possibilities afforded by new methods of design.—*Engineering Record.*

An interesting comparison between steam turbines and reciprocating engines in regard to their dimensions and the space occupied is given in the *International Marine Engineering.* The comparison is made between the cruiser *Salem*, fitted with steam turbines, and the battleship *Vermont*, fitted with triple expansion reciprocating engines. The comparison is direct, inasmuch as the requirements are for about 8,000 horsepower in each case. The dimensions, as given, are as follows:

	Turbine.	Engine.
Length over all.....	16 ft. 2¾ ins.	33 ft. 6½ ins.
Width over all.....	13 ft. 6 ins.	11 ft. 3 ins.
Height over all.....	12 ft. 6 ins.	21 ft. 9 ins.
Floor space.....	219 sq. feet.	377 sq. feet.
End area.....	169 sq. feet.	245 sq. feet.
Side area, or target....	203 sq. feet.	730 sq. feet.
Over all volume.....	2,735 cu. feet	8,200 cu. feet.

In the above tables the areas and volumes are figured out from the gross dimensions in each case, and are, therefore, strictly comparable. The turbine shaft over all measures 23 feet 7 inches, while the crankshaft of the engine is 31 feet 1 inch. The length from center to center of main bearings of the turbine is 18 feet 6 inches, corresponding to 25 feet 8½ inches from center to center of main bearings of the engine. The length over the stuffing boxes of the turbine is 14 feet 5½ inches. The length over all of the cylinders of the engine is 32 feet 9 inches. In the table the figures for the turbine are based on the over-all dimensions of the casing.

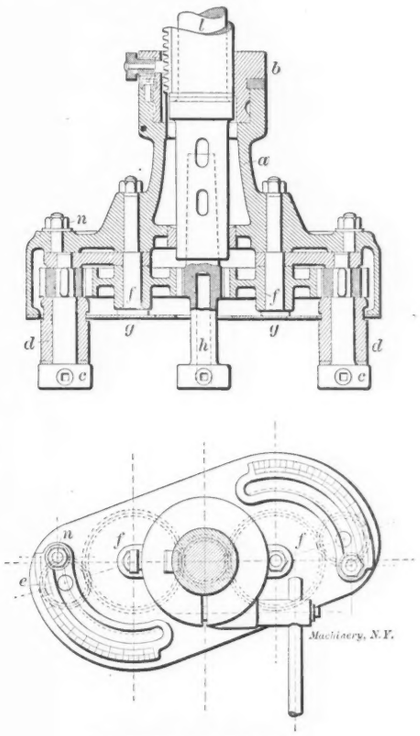
LEAKAGE IN COMPRESSED AIR PLANTS.

Some statements in *Compressed Air* in regard to the cost of leakage in compressed air plants are well worth consideration. Few people realize that leakage plays an important part in the efficient operation of a compressed air plant. Many concerns will go to great expense in installing high class air compressors with compound steam cylinders and two stage air cylinders, but when it comes to installing the pipe line the utmost carelessness is displayed, the same fittings being used that would apply to a steam line without the fact being taken into consideration that steam and air are two very different mediums. The heat of the steam tends, of its own accord, to keep joints tight which, if cold, would leak considerably. In manufacturing establishments, particularly, with a compressed air plant with a capacity of, say, about 500 cubic feet per minute, where the air plant is of a more incidental character than in the case of a central air power plant, the percentage of leakage is usually very high owing to the fact that less pains are taken in the installation of machinery and piping in smaller and cheaper plants than is the case with the larger and more expensive ones. Furthermore, most manufacturing establishments require a more complicated distribution of the compressed air and the installation of more valves, bends and outlets is needed. It is fair to consider the leakage as being 2 per cent in a manufacturing plant. The compressor will very likely be a single stage one and the horsepower required to compress the leakage of 10 cubic feet per minute to 100 pounds pressure will be $0.207 \times 10 = 2.07$. At 2 cents per horsepower per hour this leakage would cost 41.4 cents per ten hour day, or $124.20 per year.

THREE-SPINDLE DRILL HEAD.

Very often when three holes are required to be drilled in a line, they are spaced equidistant. In such a case a simpler arrangement than that of the ordinary multispindle drill for drilling all the holes at once can be devised. Such an arrangement is shown in *The Practical Engineer*, issue of November 16.

The sectional elevation and plan of the device show the general arrangement. The bushing *b* is mounted on the spindle sleeve of a drilling machine, and is held in position by means of a bolt tightened against the rack. On this bushing



Three-spindle Drill Head

the housing *a* is secured in such a manner that it can be turned round, and thus the drills adjusted to suit the work. The housing *a* can be firmly clamped on the bushing *b* in any desired position.

The driving of both adjustable spindles *c* is effected through the intermediate pinions *f*, meshing into the toothed chuck *h*, which is inserted in the lower end of the spindle *l*. The spindles *c*, with their bearings *d*, engage with the bolts *g*, and can be swung round these and thus be quickly and accurately adjusted, and be fixed in position by nuts *n* to the required pitch of holes by means of dials attached to the housing.

TIN LEAD ALLOYS AS SOLDERS.

The Iowa Engineer, September, 1906.

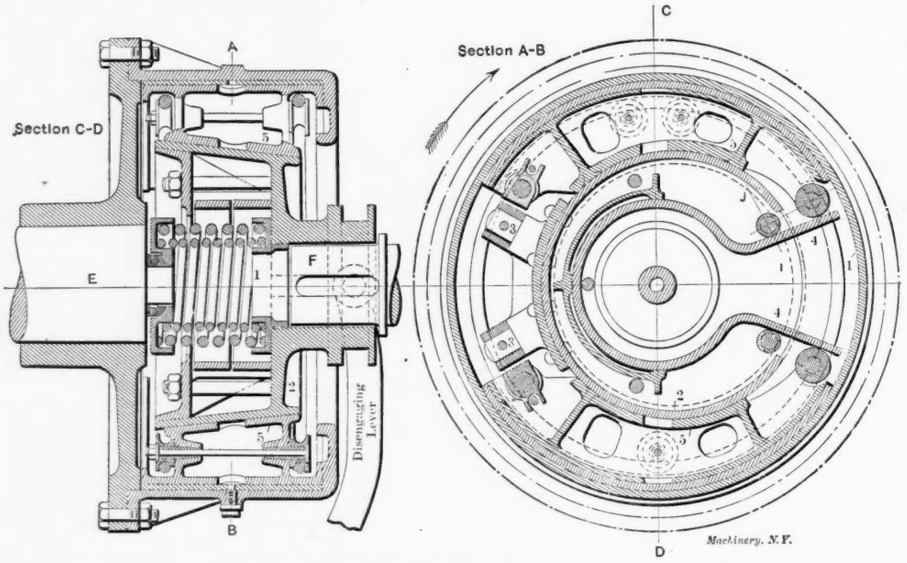
The properties of tin lead alloys used as solders have not been very extensively investigated, although their use is universal. For this reason experiments were made at the Iowa State College in order to ascertain which would be the most preferable method of making soldered joints, as well as their tensile strength. As to the methods of making soldered joints it was found that any pressure whatever upon the solder at the moment of setting greatly reduced the strength of the joint. When making a soldered joint, therefore, the upper piece should be supported above the lower one, the solder be fused by means of two blow torches and the pieces brought together with very gentle pressure. This method differs from the most common one or that of "sweating." In regard to the strength of soldered joints, it was found that the time element made a decided difference in the tests, and could not be eliminated. For instance, a decrease of 5 seconds in the total time of testing increased the strength 4,000 or 5,000 pounds per square inch, the total time of testing being from 20 to 25 seconds. The maximum strength obtained under

any circumstances was 25,900 pounds per square inch with a joint on copper with solder containing 60 per cent tin. The total time of this test was 20 seconds. As to the influence of the amount of tin in the solder the tests showed that the maximum strength increases with a percentage of tin, but if the time element is considered, the average strength increases only up to 60 per cent of tin and then decreases. For this reason 60 per cent of tin in the solder must be considered as most suitable for general work, but for work requiring little mechanical strength, such as "sealing," a lower percentage of tin might be used.

GRADUAL APPLICATION CLUTCH.

Attention is called by *Engineering* to a gradual application clutch, known as the Michel grip clutch, designed by a French engineer.

On the end of the shaft *E* is keyed a flange, to which is bolted a cylindrical casing, forming the exterior of the clutch. The sliding portion of the clutch keyed to the shaft *F* consists of a male cone, marked 2 in the cut, eccentric to the line of the shafts, and having a portion of one side cut away. In the interior of the cone is a curved plate-spring with the ends projecting through the opening, and constrained by two fixed stops just inside the cone. On the back of the cone,



Michel Gradual Application Clutch.

opposite the opening, is riveted a bracket, carrying two pins, marked 3, and surrounding each pin is a buffer, fastened to it by a taper pin. In the space on each side of the cone, between it and the casing, is a curved tapered shoe. These shoes carry buffers at their larger ends, opposite the cone-buffers just mentioned, and round collars, surrounding pins at the smaller ends of the shoes, act also as buffers against the ends of the plate spring. Pins with grooved collars at each end are fastened through the centers of the shoes, two through one shoe and one through the other. These are shown in side elevation and dotted in the section *A B*. A spring-ring passes round the grooves in the collars, and holds the shoes against the cone.

The action of the clutch is as follows: When the disengaging lever is relieved, the helical springs, shown in section *C D* force the cone home against the inner faces of the shoes, and the latter are pushed outward in contact with the casing. If the casing is revolving in the direction of the arrow, as soon as the shoes come in contact with it, the upper one tends to be drawn into a narrower portion of the annular space against the action of the plate spring. It is thus tightened between the cone and the casing until there is sufficient friction to transmit the drive. The lower shoe, on the contrary, is loosened and pushed back against the cone buffer, so that it takes no part in the transmission of power. It is clear that if the revolution of the casing were in the other direction, the drive would be equally efficient, the lower shoe then transmitting the power.

TRADE SCHOOLS IN SWEDEN.

At the same time as the question regarding efficient trade schools is coming to the front in this country it has received a great deal of attention everywhere in Europe. According to *Teknisk Tidskrift* the city council of Stockholm, Sweden, is contemplating a system of completely organized trade education, the main features of which may be of interest wherever this question is considered.

The school contemplated for the mechanical trade would require the pupils to attend all the six days in the week for four years, the total number of hours per week being 50 for the two first and 54 for the two last years in the course. The practical work in special shops provided would occupy 32 hours during the two first years and 42 hours a week during the two last years. The remaining hours would be given up to studies on subjects connected with the trade. These subjects would be free hand and mechanical drawing, fundamental mathematics and the elements of mechanics, calculations of areas and weights, the first principles of machine design and subjects of general nature connected with mechanical work. The requirements for entering these trade schools are to be a complete grammar school course. For persons that have already entered in industrial work a course will be provided where attendance will be expected only one day a week. In this course the subjects will be exclusively theoretical, since the pupils will get a practical training during the five days in the week during which they engage in the trade. It must, of course, be expected that employers will realize the necessity, as well as the advantage to themselves, of this trade education so that there will be no difficulties in regard to setting apart one day for educational purposes. Should difficulties arise it is likely that the government will duly assert its influence in behalf of the young men looking for more complete education in the trade. The shops are to be equipped as modern and complete as possible. Only men of practical ability who have been a long time actually engaged in industrial pursuits will be engaged as instructors. This will insure that the schools will give instruction of an equally up-to-date nature as what could be obtained from actual experience in manufacturing establishments. The cost for establishing schools for the various trades is estimated to be about $350,000 and the yearly maintenance to about $35,000. The city authorities as well as the national government of the country will provide the means necessary. When in complete condition the schools will probably provide for about 500 students attending the daily courses and 1,200 additional attending the courses where instruction is given only one day a week. In order to insure earnestness of purpose of the students who enroll and add to their desire to follow up this purpose a fee of about $5.00 per year will be charged. This is not so much for the purpose of providing any income to the schools as to inculcate the idea of the value of the instruction, inasmuch as things that can be had for nothing as a rule are valued less than those for which a payment is required, even if this payment is only nominal.

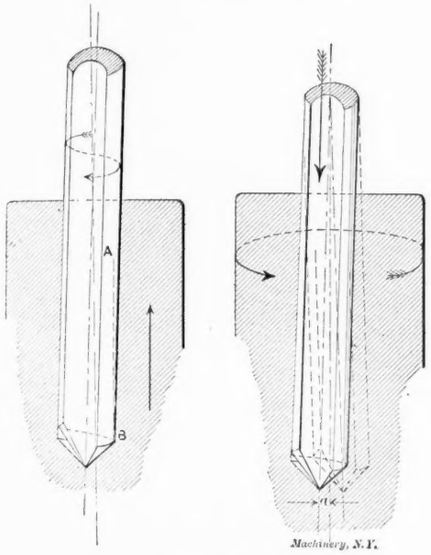
THE DRILLING OF DEEP HOLES.

The *Zeitschrift für Werkzeugmaschinen und Werkzeuge* gives an account of the drilling and boring of a hole 4¾ inches in diameter, through a shaft 147½ feet long. The principles governing the drilling and boring of deep holes are discussed, and are summarized in the following:

The difficulties to be overcome in producing deep drilled holes can be classified in three groups. In the first place the

drill has a great tendency to run out, thus producing a hole that is neither straight, nor uniform in diameter; in the second place great difficulties are encountered in trying to remove the chips in a satisfactory manner, and in the third place the heating of the cutting tool is difficult to prevent.

The principle involved in common drill presses where the drill is given a rotary motion simultaneously with the forward motion for feeding is the one least adapted to produce a straight and true hole. Better results are obtained by giving only a rotary motion to the drill, and feeding the work toward it. It has been found, however, that for drilling deep holes the reversal of this, that is, imparting a rotary motion



Drilling of Deep Holes.

to the work, and the feed motion to the drill will answer the purpose still better. It seems as if there could be no material difference between the latter two methods. An analysis of the conditions involved will show, however, that there is a decided difference in the action of the drill. If the drill rotates, and the work is fed forward as shown to the left in the cut, the drill when deviating from its true course will be caused to increase its deviation still more, by the wedge action of the part *B*, which tends to move in the direction *A B* when the work is fed forward. In the case of the work rotating and the drill being fed forward, as shown to the right in the cut, the point of the drill when not running true will be carried around by the work in a circle with the radius *a*, thus tending to bend the drill in various directions. The drill is by this action forced back into the course of "least resistance," as it is evident that the bending action, being exerted on the drill in all directions, will tend to carry the point back to the axis of the work where no bending action will appear. The chips, as is well known, are carried off by forcing a fluid into the hole, which upon its return carries with it the chips. This fluid being oil will serve the double purpose of carrying away the chips and lubricating the cutting tool, keeping it at a normal temperature.

THE WEIGHT OF A CROWD PER SQUARE FOOT.

From *Engineering*, September 21, 1906.

To the structural engineer the possible normal weight of a crowd of people is an important factor of calculation. The prevalent custom has been to accept as a basis the recommendations of Trautwine, who advanced the theory that on bridges for turnpikes and common roads no probable contingency could crowd people to such an extent as to weigh more than 80 pounds per square foot of floor and that this might safely be taken as the maximum load on spans of 20 feet or more. To compensate, however, for impact, he recommended to adopt 100 pounds as the limit for crowds. In engineering practice both in this country and America this formula is more or less accepted. Trautwine refers in substantiating this theory to a test made by a Mr. Nash who wedged as closely together as possible a group of men within a 20-foot diameter, the last man admitted being lowered down from above. In this extreme case a result of 120 pounds per square foot was obtained. But this weight has since been exceeded by a number of experimenters, notably by Prof. Johnson of Harvard, who, in 1904 obtained a weight of 164.9 pounds per square foot. When these results were published they caused considerable comment, by some American engineers in particular. Prof. Johnson therefore undertook to see exactly what the limit was.

A wooden compartment or pen 6 feet by 6 feet was constructed, placed on the ground securely braced to the walls of a building and furnished with a door which could be closed by a strong wooden bar. Various photographs were taken at different degrees of compactness from above. One hundred pounds was easily obtained without any discomfort to the men; 154.2 pounds per square foot was easily reached by 37 men who arranged themselves as they saw fit. Finally 40 men of more than average weight were forced within the area of 36 square feet and a final test gave a load of 183.3 pounds per square foot. This result is additionally remarkable from the fact that though tightly packed the 40 men experienced no serious discomfort and could move their limbs with little difficulty. The only distress which was met with was that suffered when they all tried to breath deeply at the same time. It is evident from Prof. Johnston's investigations that a weight of 140 pounds per square foot is quite feasible where there are throngs of people all headed one way, while a load of 80 pounds per square foot is quite a common thing in buildings and private houses where social gatherings are frequent.

LOADING OF ROPE.

A little taste of elementary mechanics is sometimes worth while. We must not forget that while the action of all mechanisms is controlled by simple principles, these principles are not always as well understood as they should be by men who have the handling and care of property worth many thousands of dollars, to say nothing of the danger to human life caused by seemingly inexcusable ignorance. These remarks apply with special force to the handling of material by cranes or derricks, using ropes and sheave blocks. A careless workman may see a load of several tons handled safely

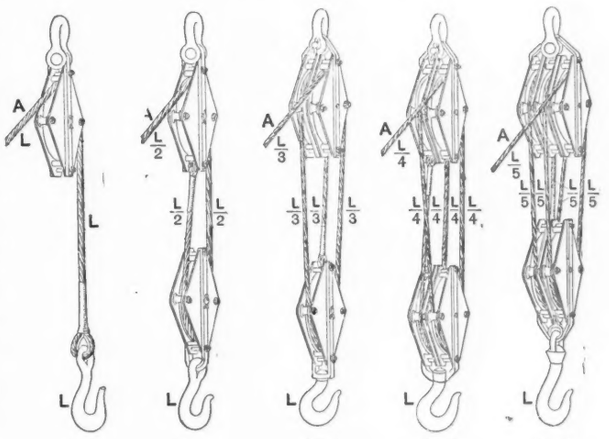


Fig. 1 Full load on rope

Fig. 2 Strain on rope is one-half the load

Fig. 3 Strain on rope is one-third the load

Fig. 4 Strain on rope is one-fourth the load

Fig. 5 Strain on rope is one-fifth the load

with pulley blocks and a wire rope of perhaps not more than ½ inch diameter. The construction of the pulley blocks which permit of such a load being safely handled of course comprises a number of sheaves in both a stationary and moving block which divide the load among several ropes. For example, the accompanying cut taken from the *American Wire Rope News* (with a slight change) illustrates the conditions in loading on a rope with pulley blocks. The first figure shows that with one block the total load on the hook is transmitted to the rope at *A* but in Fig. 2 only half the load is so transmitted, and progressively up to Fig. 5 we find that only one-fifth of the load on the hook is carried by the rope at *A*. So supposing that the tackle will safely carry ten tons on the hook it by no means follows that the wire rope

alone will carry that load. On the contrary the chances are that it would not sustain it at all unless a high factor of safety was employed. The cuts show graphically the division of loading among the sheave ropes, being respectively $\frac{L}{2}$, $\frac{L}{3}$, $\frac{L}{4}$, and $\frac{L}{5}$.

THE LENTZ REVERSING MECHANISM.

A few months ago the *Zeitschrift des Vereines Deutscher Ingenieure* described the simple but ingenious Lentz reversing mechanism. Fig. 1 shows the general arrangement of the design, and in Fig. 2 a section of the detail which is particularly novel is given.

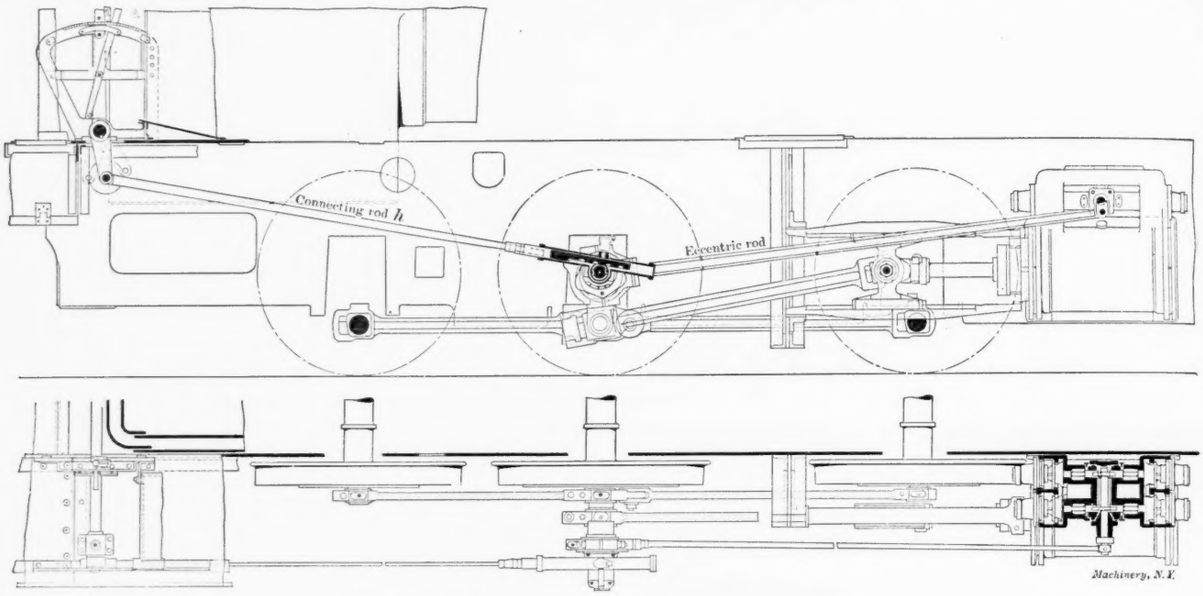


Fig. 1. General Arrangement of the Lentz Reversing Mechanism.

As seen from the cut, the crankpin is provided with an outside extension which carries a stud *f*. On this stud the eccentric *a* is mounted, and is free to move around the stud as a center. A bushing *b* is movable along the stud *c*, which is located in line with the wheel axle. This bushing is keyed to the stud by means of the key *d*, and will thus rotate with the wheels. The bushing is provided with spiral teeth on the outside, which mesh with teeth in the eccentric *a*. It is evident that a longitudinal movement of the bushing *b* will move the eccentric around the stud *f*. On the outside of the bushing *b* there is a second bushing *e* which is keyed to the final cover *k*, and is stationary in regard to the rotary motion of the bushing *b*, but moves with this latter bushing in a longitudinal direction by means of four flanges, *g*, on the outside surface.

This second bushing is in its turn provided with spiral teeth on the outside, which mesh with teeth in the rod *h*, connected with the regular reversing lever. It is now evident that a motion of the rod *h* in its longitudinal direction will cause the bushing *e*, and at the same time the bushing *b*, to move. The movement of the latter bushing, however, turns the eccentric around its support, and places it in any desired position. The valves themselves are operated by a horizontal shaft, turned by a small crank connected with the eccentric rod. The advantages claimed for this design are the comparatively small number of parts, and the possibility of making the mechanism perfectly dustproof. This construction has been practically tried in Germany in at least two instances, and proven to work entirely satisfactory. It is known as the Lentz reversing mechanism.

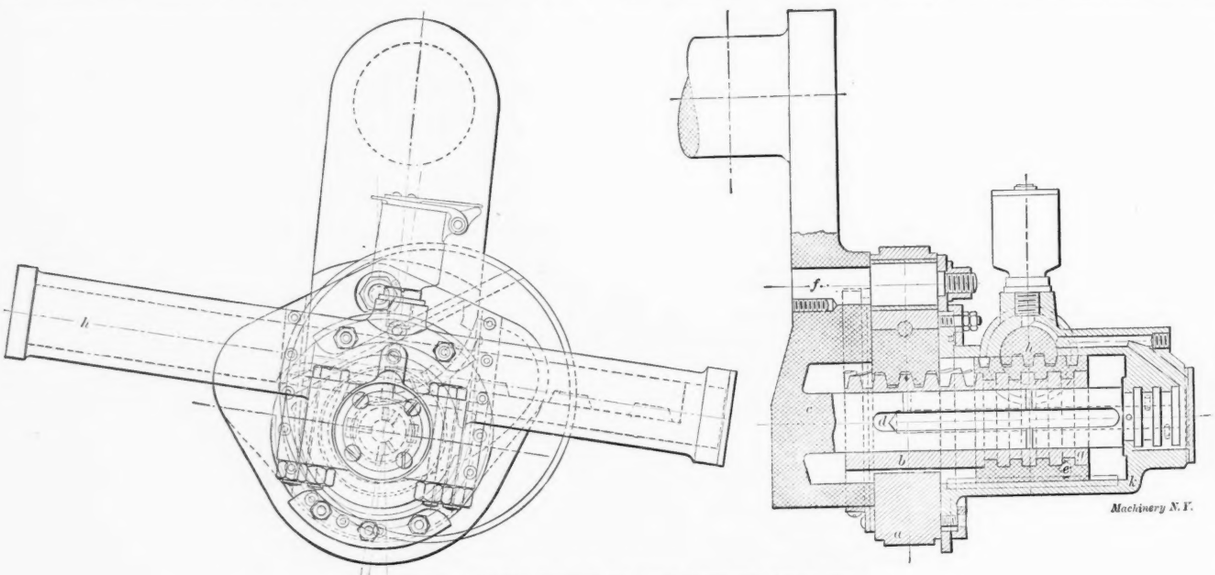


Fig. 2 Section and Side View of the Lentz Reversing Mechanism.

THE UNITED STATES CENSUS OF MANUFACTURES, 1905.

Bulletin 57, Department of Commerce and Labor

A few statistical figures from the latest bulletin of the Department of Commerce and Labor are of interest on account of the conclusions which can be drawn in regard to the in-

crease of the manufacturing in the United States during the last five years. The number of establishments in 1905 had increased by 4.2 per cent, the capital invested by 41.3 per cent, and the value of the products by 29.7 per cent, as compared with 1900. It will be noted that the value of the product had not increased in the same ratio as the invested capital, a fact which seems to point out that the large modern industrial establishments are not of necessity more productive than the smaller ones of former years. This conclusion is also borne out by a number of other statistical figures contained in the bulletin, particularly in reference to concerns of the corporation class, inasmuch as the figures given show that the large incorporated companies do not produce as much in proportion to the large capital investment as do the smaller firms and individual concerns. Thus 82.8 per cent of all the capital invested in industrial establishments comes on the corporations' share, but the value of the products of these same corporations is only 73.7 per cent of the total value of all manufactured goods. On the other hand, the firms with 9.4 per cent of the total capital produced 14.4 per cent of the total value of products, and individual concerns with only 7.6 of the capital produced 11.5 per cent of the total. This seems to indicate that the greater saving of expenses which was claimed to be incident to the large corporations is fictitious. In fact it is so much more a proof of the failure of the corporations as compared with some individual concerns as the figures do not show the unfeasibility of the large concern as such, but merely the unproductivity of establishments in corporate form. This statement is borne out by the fact that 1,899 concerns with an output valued at a million dollars or more each and controlling a capital of 37.7 per cent of the total, show value of the product of 38 per cent of the total. This seems to indicate that it is not the large concern as such which meets with difficulties, but it is the large concern when not individually conducted, but conducted as a corporation. The figures, however, show the greatest productivity in proportion to the invested capital for concerns the value of whose annual output does not exceed $20,000.

The average number of wage-earners employed during 1905 was 5,470,321 as compared with 4,715,023 in 1900. The increase of wage earners is thus proportionally far smaller than the increase of the value of the product which shows the tendency of modern machinery to displace manual labor, not by eliminating it but by making possible a larger per capita output. The greatest number of wage earners employed at any one time during 1905 was 7,017,138 and the least 4,599,091. This seems to indicate that a great number of people can secure only very unsteady employment, and that the modern manufacturing methods are augmenting the problem of the unemployed. The average number of children employed were 159,899, as compared with 161,276 in 1900, or a decrease of less than 1 per cent. Pennsylvania ranks first and Massachusetts second in the number of children employed. The greatest numbers in both of these states are shown for the textile industries. In regard to wages paid, these show an increase over the figures of 1900 very nearly in the same proportion as the increase in the value of the product.

The motive power employed in manufactures increased from 10,409,625 horsepower in 1900 to 14,464,940 horsepower in 1905, or an increase of 39 per cent, which is considerably higher than the increase in the value of the products. The statistical figures indicate that the large manufacturing plants have a tendency to remove from the large cities to rural places. While the increase of capital invested in urban establishments was 34.2 per cent, the increase for the rural plants is 58.7. In all respects the establishments located in rural districts show a higher percentage of increase than those in municipalities having a population of 8,000 inhabitants or more.

THE DEVELOPMENT OF THE FRAME OF AMERICAN FREIGHT LOCOMOTIVES.

The Railroad Gazette, October 19, 1906.

To the casual observer the frame of to-day would seem to be exactly like that of 25 years ago except in the matter of size. It consists of two bars, the upper one nearly square and the lower one of the same width as the upper, but narrower in vertical dimensions. These frames have always been made in two pieces, the back part containing the pedestals for carrying the axle boxes, and the front part rails to which the cylinders are fastened. It is the splice between these two pieces which has been the object of the study for improvement. In order to show how these details have been worked out step by step a series of illustrations are given showing the various changes in detail that have been made in the development of the fastening.

Fig. 1 is the type of fastening used in the late seventies. The frame was of wrought iron, and the front rail was joined to the main frame by a T foot whose upper arm was jumped on and held by countersunk bolts. In addition to the countersunk bolts through the pedestal, there were two vertical bolts holding the front rail to the drop of the main frame, and these bolts were supposed to be relieved of shear by the key that is shown between them. With the small cylinders in use at that time this frame gave little trouble, but with an increase in the diameter of the cylinders the repeated stresses would draw the countersunk bolts down and the nuts would come loose.

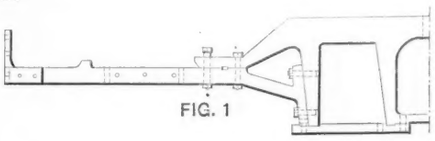


FIG. 1

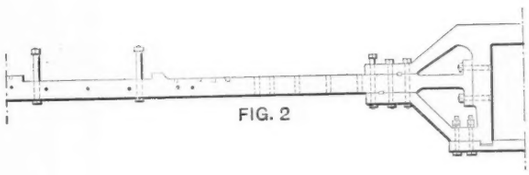


FIG. 2

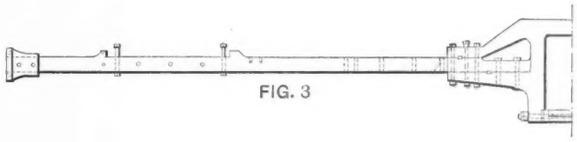


FIG. 3

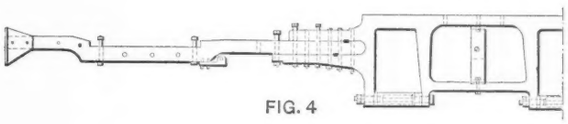


FIG. 4

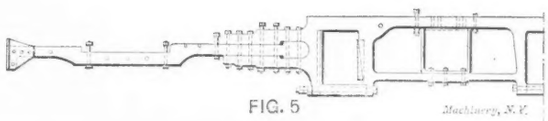


FIG. 5

This form was followed by that shown in Fig. 2. But here the countersunk bolts joining the T foot to the main frame gave trouble by breaking, because the whole load would be carried by them in consequence of the springing of the two parts of the main frame. This construction was abandoned for that shown in Fig. 3, in which the lower portion was raised and made horizontal, with the front rail laid flat upon it and held by bolts, some of which went through the upper section of the frame, to which a key was added. This form gave excellent satisfaction, with cylinders up to 18 inches diameter. Heavier engines, however, required a stronger fastening, and a direct outgrowth of the form shown in Fig. 3 is that shown in Fig. 4, in which both upper and lower jaws of the main frame are horizontal, with the front rail between them and having a key on each side. This gave excellent service for a time, but again the increase in cylinder dimensions necessitated a change. The keys, which had but a half bearing in each of the two parts between which they were placed, would twist and throw the entire stress upon the bolts. To obviate this trouble the lower frame was given a T head, as in Fig. 5, and keyed against the lips on the arms of the main frame.

Where double rails were used they were at first attached, as shown in Fig. 6, in which the lower rail had the same T head as in Fig. 1, while the upper rail was simply laid on and bolted to an extension of the upper frame. It was the standard method of construction for many years, and the only trouble experienced with it was an occasional breaking off of a T head. When this method of fastening became too weak for the increasing diameter of cylinders, the lower arm was made horizontal, but an upward bend of the front rail still left an opportunity to use the countersunk bolt through the pedestal leg, as shown in Fig. 7. This form soon yielded to that shown in Fig. 8, in which the T head was dispensed with and the front lower rail laid on like the upper one and bolted fast. This gave way to that shown in Fig. 9, in which the upper front rail was extended back over the jaw of the forward axle, while the upper arm of the main frame was run out to abut against the cylinder casting. The lower arm was lipped up into the lower rail so as to form a bearing there for all back thrust of the cylinders. This in turn was followed by that shown in Fig. 10, in which the front upper rail was lipped down over the upper arm of the main frame, as in the case of the single rail frame of Fig. 5. Strong as this construction was, the stresses imposed by the cylinders were too great and, on the latest type of heavy engines, we find the form shown in Fig. 11 in use. Here the two front rails have been united in a single deep slab, to which the cylinders are bolted. These parts are no longer cast solid with a half saddle but are separate with a saddle between. The first frames of this sort that were built had the fastenings to the main frame as in Fig. 11, but they have been followed by that of Fig. 12, in which the upper rail has been carried back over the top of the jaws and keyed as shown.

During all this period of development there has been more or less activity in attempting to produce a cast-steel frame. First efforts were not altogether successful, but the desirability of securing such a frame, on account of the facility with which provision could be made for the attachments, together with the probable decrease in the cost of machining encouraged makers to persist in the work until now cast-steel frames like that shown in Fig. 13 are constructed, which can be made complete for less than the cost of finishing a frame of the older type. The result is that, though these frames are far from having come into general use, they may be considered to represent the latest type of the frame of the American locomotive.

The back part of the frame has changed but little in form. That of the early engines is shown in Fig. 14, and this still holds with such modifications as may be required to accommodate the trailing truck of the later classes of engines or to add to the depth of the firebox by the use of the drop in the upper rail, as shown in Fig. 15.

The examples given show the tremendous amount of tentative work that has been required in order to develop the locomotive to its present condition, and the end is not yet.

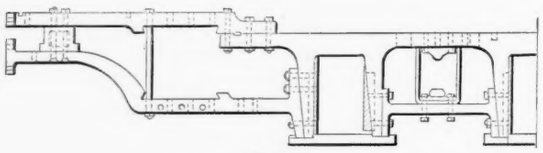


FIG. 6

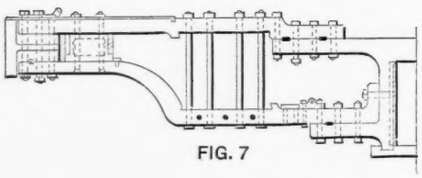


FIG. 7

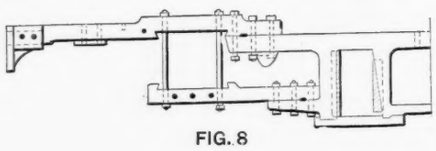


FIG. 8

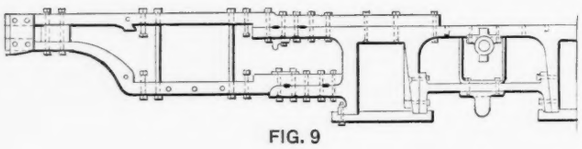


FIG. 9

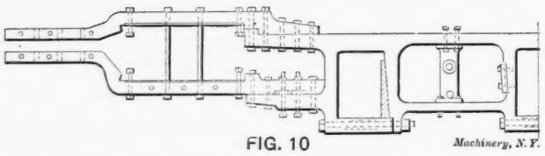


FIG. 10

Machinery, N.Y.

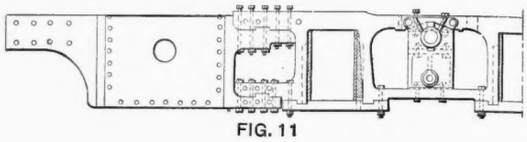


FIG. 11

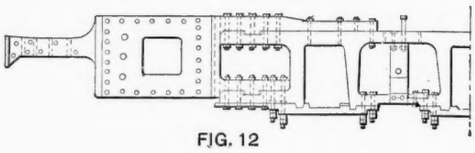


FIG. 12

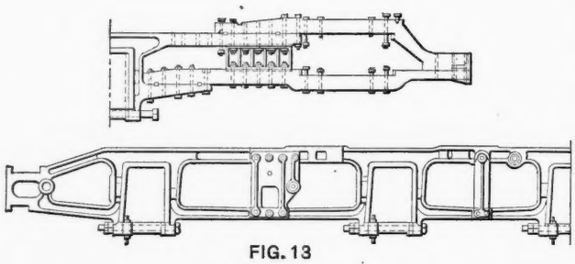


FIG. 13

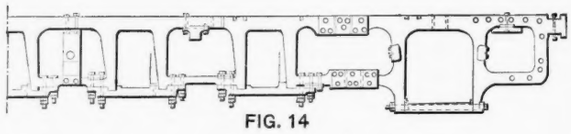


FIG. 14

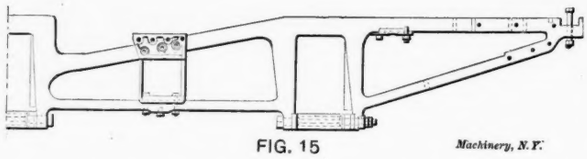


FIG. 15

Machinery, N.Y.

* * *

LAKE OF QUICKSILVER! WHO CAN BEAT THIS YARN?

"A lake of quicksilver, covering an area of more than three acres and having a depth ranging from ten to fifty feet, has been discovered in the mountains of the state of Vera Cruz. The value of the product is estimated at millions. This lake has been known to the Indians for many generations. It is situated far up in the mountains in an almost inaccessible position. Its surface is partly covered by stones. It is believed that volcanic action in the mountains above smelted the quicksilver out of the cinnabar ore and that it ran down and filled this depression. A tunnel will be driven through the base of the mountain, and the quicksilver will be brought down by means of gravity."—*News Item.*

ANNUAL MEETING OF THE A. S. M. E.

The annual meeting of the American Society of Mechanical Engineers was held in New York, December 4 to 7 at the Edison Building, No. 44 West 27th Street. The registration showed that something over 1,200 members and guests were in attendance. The entertainments provided included an inspection of the Port Morris, N. Y., power house of the electrified section of the New York Central R. R., a special train being provided for the guests on the afternoon of December 6. The crowning feature was unique, being a trip to Sandy Hook proving ground by way of the Central Railroad of New Jersey. Special arrangements were made with the United States government to show the guests the various features of the fortifications and to fire a number of large guns for their edification. The annual ball at Sherry's was held Thursday night.

The New Engineering Building.

Although not yet completed at the time of the meeting, the new Engineering Building on West 39th St., between Fifth and Sixth Aves., was open for inspection, and it naturally attracted a considerable number of the members and guests.

Fig. 1. New Engineering Building, West 39th Street, New York.

These were practically unanimous in praise of its excellence of design and construction. The building is the result of a gift of $1,500,000 by Andrew Carnegie for the founding of a joint society building which would shelter a large engineering library and be the headquarters of societies accepting the gift. These are the American Society of Electrical Engineers, American Institute of Mining Engineers and American Society of Mechanical Engineers. It will also be the headquarters of a number of minor societies interested in engineering or science. These associate societies will pay rental to the holding company in the form of yearly assessments.

This building has thirteen floors above the street level, and Fig. 1, reproduced from the architect's drawings, shows a perspective view looking northwest (see MACHINERY, January, 1906.) The library, the plan of which is shown in Fig. 2, is located on the top floor to avoid the noise, dust and confusion which would be incident to location on the lower floors. The floor given up to the American Society of Mechanical Engineers is the eleventh and the accompanying plan, Fig. 3, shows the arrangement of the rooms. The auditorium, Fig. 4, which is common to all large gatherings of the societies occupying the building, is on the second floor and seats 1,000. It has a gallery and is arranged for the utmost convenience of speakers and members. It was decided that a room having a seating capacity of 1,000 was about the limit of size in which papers could be read and discussed advantageously; a larger room would cause straining of a speaker's voice and difficulty in following the discussion. The auditorium will

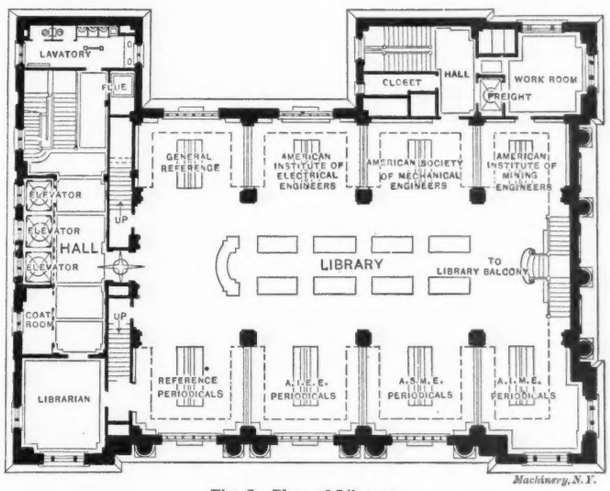


Fig. 2. Plan of Library.

hold considerably over 1,000, but the seating capacity is nominally the number given. High-speed elevators and other modern conveniences make this building a notable example of modern high-class structures. It will be a credit to all the societies connected therewith and its location only one block removed from the New York Public Library and its direct communication with the Engineering Club Building on 40th St. make a location that is ideal for convenience of research, etc. It will be easily reached from out of town, being only a short distance from the 42d St. terminal of the New York Central and New Haven Railroads and a slightly greater distance

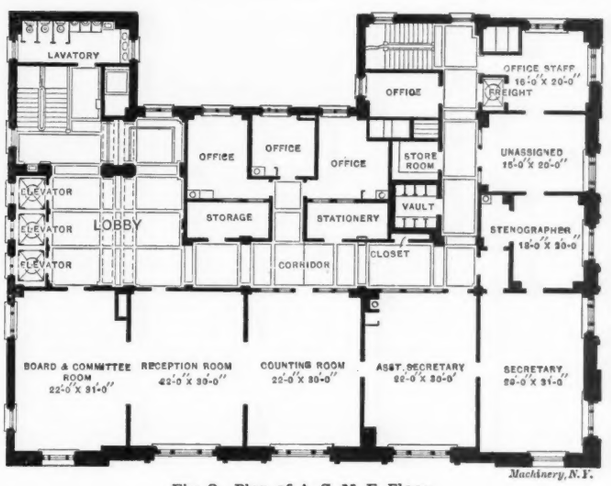


Fig. 3. Plan of A. S. M E. Floor.

from the new Pennsylvania R. R. terminal. By the time this description appears the American Society of Mechanical Engineers will have moved into their new quarters.

REVIEW OF THE PAPERS.

On the Art of Cutting Metals, by Mr. Fred. W. Taylor.

This voluminous paper, forming the presidential address, reviews the work of Mr. Taylor and his associates in determining the elements or factors which affect the efficiency of metal-working tools on roughing cuts. These investigations have extended over a period of twenty-six years and during that time over 800,000 pounds of steel and iron have been cut into chips on experimental lathes at a cost of $150,000 to

$200,000. In carrying on this work more than ten machines were fitted up at various times and literally thousands of experiments were recorded. More than 16,000 experiments were recorded with one company, the Bethlehem Steel Co. Quite as remarkable as the result is the fact that for twenty-six years the discovered laws have been kept secret and the accumulated knowledge has been used as a lever for extending the investigations. The plan was to give to each company availing themselves of the acquired knowledge of Mr. Taylor and his associates this knowledge in return for the privilege of making more experiments at the present company's expense. The paper is very voluminous, containing about 100,000 words and twenty-four large folding sheets of halftones, drawings and tables. It is one of the most notable papers ever presented before the society and it doubtless will have a great effect on future machine tool design and practice. The investigations show that there are twelve separate and distinct elements or variables affecting the efficiency of the lathe and the same applies to any metal-working tool. A full abstract of this remarkable paper will be given in sections as space permits.

Report of the Committee of Standard Proportions of Machine Screws.

At a joint meeting of representative machine screw manufacturers and individuals connected therewith, held in New York, April 11, 1904, certain diameters, pitches and limits for standard machine screws were adopted. Since that date it has been found advisable to modify the list of machine screw sizes which were agreed on at that time before final action was taken by the society; Mr. George M. Bond of the committee reported that the matter was still under discussion and that a final report could not be made until the spring meeting, 1907. See MACHINERY, June, 1906, for an abstract of the proposed machine screw standards.

The Evolution of Gas Power, by Mr. F. E. Junge.

The author points out the remarkable development of the gas engine within the memory of the past generation and shows that it has become a factor of consequence in the world's total energy output. In Germany alone at the present time there is a total of about 400 gas engines with a combined capacity of about 420,000 horsepower. He states that the variety of earlier forms of large gas engines has now been

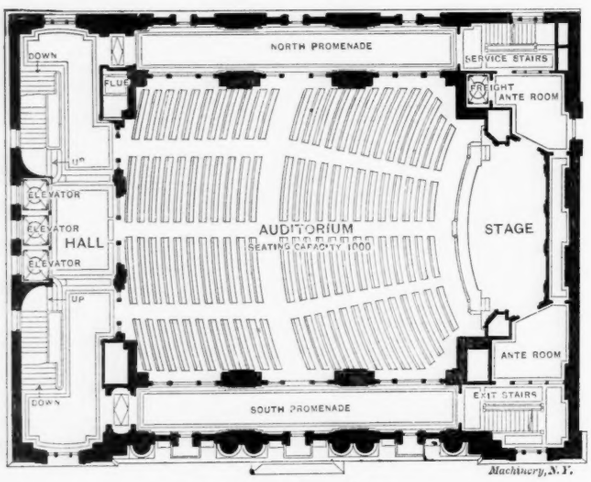


Fig. 4. Plan of Auditorium.

reduced to two classes, these being the double-acting tandem four-cycle and the double-acting two-cycle types. The single-acting type of each is only applicable in the smaller sizes. The peculiar process of charging with an open exhaust limits the two-cycle engine to speeds of from 80 to 100 as a maximum, and therefore puts this type at a disadvantage where the maximum power output is required for a given weight and space.

Producer Gas Power Plants, by Mr. J. R. Bibbins.

This timely paper on the simple producer plant calls renewed attention to its value. The author endeavors to show that the gas power plant using producer gas is a thoroughly practical form of motor power equipment; that it is reliable in operation; is suited to fluctuating loads; is comparatively simple to operate; and is more economical in point of fuel efficiency than the average steam plant of the same size and capacity.

Tests of High Duty Air Compressors, by Prof. O. P. Hood.

In the copper country of Michigan several compressed air plants exceed 1,000 horsepower each and there is one of about 5,000 horsepower. This paper reports the result of tests of a high-duty air compressor installed at the Champion copper

Prof. Frederick R. Hutton, Newly-elected President of the A. S. M. E.*

mine at Painesdale, Mich. The machine, built by the Nordberg Mfg. Co., Milwaukee, Wis., consists of four horizontal engines placed side by side and connected to a crankshaft carrying three flywheels. The engine was designed to use steam at 300 pounds pressure and was guaranteed to develop 180,000,000 foot-pounds for each million heat units used and to compress 9,000 cubic feet per minute to a pressure of 80 pounds gage at 76 revolutions per minute. The report of the tests is given in detail. It was found that owing to boiler leakage the calculated pressure of 300 pounds could not be carried and it was necessary to use the reduced pressure of 250 pounds. It was under these conditions that the contract was carried out and the tests made. The standard efficiency tests were, heat consumed by engine per I.H.P., 10,157 B.T.U.; heat consumed per hour per B.H.P., 11,382 B.T.U.; equivalent coal consumption per I.H.P., 1.016 pound; the same per B.H.P., 1.138 pound. The duty developed per million heat units supplied to the engine was 194,930,000 foot-pounds. This engine establishes a new low record for heat consumed per hour per I.H.P., being 9 per cent lower than that used by the Wildwood pumping engine reported in 1900.

Boiler and Setting, by Mr. A. Bement.

The objects proposed in this design of boiler setting are the attainment of a perfect and smokeless combustion, and the full utilization of boiler heating surfaces. The setting is applied to a water-tube boiler of the Heine type, equipped with chain grate stokers. The setting is so constructed that the gases from the firebox traverse backward to the rear of the boiler, passing under a furnace roof of peculiar construction, upward through the water tubes, then downward, repeating this circuitous path around the baffle plates until all the gases

* Frederick Remsen Hutton was born in New York City, 1853. He graduated from Columbia College in 1876; later he was made instructor in mechanical engineering and in 1892 succeeded to the chair of engineering of that institution. The American Society of Mechanical Engineers was organized in 1880 and in 1883 Prof. Hutton was made secretary, which position he has held up to the assumption of the presidency of the society at the conclusion of the December meeting. During his incumbency as secretary of the society it has grown enormously in membership and prestige. A magnificent society building of which the American Society of Mechanical Engineers is one-third owner has been constructed. Prof. Hutton is the author of a number of technical books, including Heat and Heat Engines; Gas Engines; Mechanical Engineering of Power Plants, etc. Notwithstanding his manifold duties as head of the mechanical department of Columbia University and secretary of the society, he has been active in other work connected with his profession.

have passed around the water tubes five times, when they escape past the boiler into the stack. The results are gratifying in point of smokelessness and efficiency of fuel consumption. The principal feature is the refractory tile roof construction employed for making the gases traverse to the rear of the furnace under the water tube, before coming in contact with cooling surfaces. In short the design of the furnace is such as to secure perfect combustion first; then the utmost utilization of the heat produced.

Steam Plant of the White Motor Car, by Prof. R. C. Carpenter.

This paper describes in detail the remarkable superheated steam boiler and compound engine plant with which the White automobile is equipped. The boiler is of the continuous flow or single-tube type, or what is sometimes called the "flash" type. The engine is compound with piston valves. It exhausts into an air condenser. The dimensions of the engine tested were 3 and 6 inches diameter by 4½ inches stroke, with a rating of 30 horsepower. Its weight complete was 328 pounds and the total weight of the boiler is 275 pounds, making the total weight of the combined engine and boiler 603 pounds. The pressure averaged 303 pounds per square inch and the steam was superheated, the temperature at the steam chest averaged 757 degrees F. The results were remarkable. The best showing was an average of 12.7 pounds of steam consumption per developed horsepower per hour.

Ventilation of the Boston Subway, by Mr. H. A. Carson.

The Boston Subway system is about 3½ miles long and the general scheme of ventilation is that the fresh air shall be drawn in at the stations or portals and the vitiated air shall be discharged at points midway between the passenger stations. The paper is illustrated with photographs and drawings showing how the ventilation scheme was worked out.

Flow of Liquids in Venturi Tubes, by Mr. E. P. Coleman.

This paper is an investigation of the properties of the Venturi tube and its object was to prove or disprove the accuracy of the Venturi tube as a meter for gas and vapors at comparatively low throat velocities. The Pitot tube was used as the instrument for comparison on account of its proven accuracy and its simplicity. The result of the experiment is an apparent close agreement of the theoretical flow of air through a Venturi meter and the flow as derived from a Pitot tube observation.

Tests of an Elevator Plant, by Mr. A. J. Herschmann.

This paper is an account of the tests made on the plunger type elevators forming the equipment of the elevator plant of the Trinity Building, New York City, while in regular operation. Two series of tests are tabulated. In the first a duplex compound pump was used; and in the second, a flywheel pump. It was found that the cost of coal per car-mile was 5.22 cents with the flywheel pump and 8.04 cents with the duplex compound pump.

Test of a Rotary Pump, by Prof. W. B. Gregory.

This is an account of the test of a rotary pump installation consisting of four units of the cycloidal rotary pump erected on the Neches Canal Co.'s property near Beaumont, Texas. The pumps were driven by 18 x 36 x 48-inch tandem compound condensing Corliss engines direct connected. The displacement of each pump is 605 gallons per revolution. The water is elevated 32 feet. It was found that the mechanical efficiency of the two pump units average 83.3 per cent.

Improved Transmission Dynamometer, by Prof. W. F. Durand.

The paper calls attention to a modified form of Tatham dynamometer in which four sprocket wheels are used all in one plane with an automobile or bicycle chain connector instead of leather belt, thus giving a non-slip drive. The load is measured by the turning moment of the beam carrying the two idler wheels, the other two being mounted on stationary bearings.

A Plan to Provide Skilled Workmen, by Mr. M. W. Alexander.

This paper is an account of the work of the General Electric Co., at West Lynn, Mass., in training boys and young men to become practical machinists and patternmakers. The General Electric Co. have established two training rooms, one for machinists and toolmakers, with about 10,000 square feet of floor space and about 105 representative machine tools; and a smaller department for wood and metal patternmaking apprentices, with a floor space of about 1,000 square feet. The paper is coördinate with the article by Mr. Alexander which appeared in the September issue of this journal.

Saw-tooth Skylight in Factory Roof Construction, by Mr Fred S. Hinds.

The saw-tooth roof was developed to meet the needs of the textile industries. When the power cotton loom first came into use, weaving was carried on in the homes of operatives and the natural growth due to the advent of the power loom in these small establishments led to the addition of one-story structures, which, as business increased, were added to, forming what is known as a "weave shed." As these came to cover large areas it was necessary to provide roof lighting and the saw-tooth form of roof skylight was the result. Mr. Hinds' paper is illustrated with drawings showing the construction of various forms of saw-tooth roofs, and is also illustrated with photographs of the B. F. Sturtevant Co.'s plant. This plant was described and illustrated in MACHINERY, October, 1905.

Ferroinclave Construction, by Mr. A. E. Brown.

The ferroinclave roofing is a reinforced concrete structure consisting of No. 24 soft steel sheets with dovetail corrugations filled with cement mortar on both sides, so that the slab is about 1⅜ inch thick. The paper describes the structure of this roofing and gives tests of strength under various loading conditions. For an illustrated description of ferroinclave roofing see MACHINERY for October, 1903.

Saw-tooth Roofs for Factories, by Mr. K. C. Richmond.

The author defines a saw-tooth roof as a general form of skylight, a cross-section of which approximates a 30 x 60-degree draftsman's triangle with the hypothenuse horizontal, the right angle being at the top and the glass in the short leg only. These saw-teeth may be used singly, of any convenient length, and in successive rows or in any desired combination to suit any particular conditions. The object of the saw-teeth is to obtain overhead light and in most cases the windows are faced directly or nearly north. This form of roof lighting has found wide application in many kinds of factory service, including machine shops, textile mills and other plants where a large volume of diffused light is desirable. In the latitude of New York an angle of 17 degrees to 18 degrees may be employed for the glass section and still keep out the sun in the longest summer days, and this angle may be increased from 25 to 30 degrees if a small projecting cornice is built above the window. The paper is illustrated with drawings of various types of wood frame saw-teeth and is accompanied by a general discussion of the various features affecting this form of lighting. It is pointed out that in textile industries a better class of help is attracted by the good lighting afforded by the saw-tooth roof construction.

Our Present Weights and Measures and the Metric System, by Mr. Henry R. Towne.

This scholarly paper is a discussion of the present weights and measures and it advocates an improvement to the end that the system shall be uniform with that of Great Britain. The United States liquid gallon contains 231 cubic inches, while the imperial or British wine gallon contains 277.274 cubic inches. There should be an agreement between the two. Mr. Towne is opposed to the introduction of the metric system and quotes extensively to show that its introduction would mean a revolution in existing conditions which is unthinkable from a practical standpoint. He recommends the creation of a technical commission by Congress which shall study and report on the whole subject of weights and measures.

Mechanical Engineering Index, by Profs. W. W. Bird and A. L. Smith.

This paper is descriptive of the engineering index in the department of mechanical engineering of the Worcester Polytechnic Institute. The paper includes nearly 500 heads, 1,100 sub-heads, and the cross references, all amounting to fifty-six pages of the proceedings. To any one interested in the subject of intelligent and comprehensible indexing of engineering literature the paper is well worth attention.

ON THE ART OF CUTTING METALS.--1.*

FRED. W. TAYLOR.†

Fred. W. Taylor.

The experiments described in this paper were undertaken to obtain a part of the information necessary to establish in a machine shop our (Taylor) system of management, the central idea of which is:

A. To give each workman each day in advance a definite task, with detailed written instructions, and an exact time allowance for each element of the work.

B. To pay extraordinarily high wages to those who perform their tasks in the allotted time, and ordinary wages to those who take more than their time allowance.

There are three questions which must be answered each day in every machine shop by every machinist who is running a metal-cutting machine, such as a lathe, planer, drill press, milling machine, etc., namely:

a. What tool shall I use?
b. What cutting speed shall I use?
c. What feed shall I use?

Our investigations, which were started twenty-six years ago with the definite purpose of finding the true answer to these questions under all the varying conditions of machine shop practice have been carried on up to the present time with this as the main object still in view.

The writer will confine himself almost exclusively to an attempted solution of this problem as it affects "roughing work"; *i.e.*, the preparation of the forgings or casting for the final finishing cut, which is taken only in those cases where great accuracy or high finish is called for. Fine finishing cuts will not be dealt with. Our principal object will be to describe the fundamental laws and principles which will enable us to do "roughing work" in the shortest time, whether the cuts are light or heavy, whether the work is rigid or elastic, and whether the machine tools are light and of small driving power or heavy and rigid with ample driving power.

In other words, our problem is to take the work and machines as we find them in a machine shop, and by properly changing the countershaft speeds, equipping the shop with tools of the best quality and shapes, and then making a slide rule for each machine to enable an intelligent mechanic with the aid of these slide rules to tell each workman how to do each piece of work in the quickest time.

The three great questions, as to shape of tools, speed, and feed, above referred to, are daily answered for all of the men in each shop far better by our one trained mechanic with the aid of his slide rule than they were formerly by the many machinists, each one of whom ran his own machine, etc., to suit his foreman or himself. It may seem strange to say that a slide rule enables a good mechanic to double the output of a machine which has been run, for example, for ten years by a first-class machinist having exceptional knowledge of and experience with his machine, and who has been using his best judgment. Yet, our observation shows that, on the average, this understates the fact.

Twelve Variables Affect the Production of Chips.

To make the reason for this more clear it should be understood that the man with the aid of his slide rule is called upon to determine the effect which each of the twelve elements or variables given below has upon the choice of cutting speed and feed; and it will be evident that the mechanic, or expert or mathematician does not live who, without the aid of a slide rule or its equivalent, can hold in his head these twelve variables and measure their joint effect upon the problem.

These twelve elements or variables are as follows:

a. The quality of the metal which is to be cut;
b. The diameter of the work;
c. The depth of the cut;
d. The thickness of the shaving;
e. The elasticity of the work and of the tool;
f. The shape or contour of the cutting edge of the tool, together with its clearance and lip angles;
g. The chemical composition of the steel from which the tool is made, and the heat treatment of the tool;
h. Whether a copious stream of water, or other cooling medium, is used on the tool;
j. The duration of the cut, *i. e.*, the time which a tool must last under pressure of the shaving without being reground;
k. The pressure of the chip or shaving upon the tool;
l. The changes of speed and feed possible in the lathe;
m. The pulling and feeding power of the lathe.

Broadly speaking, the problem of studying the effect of each of the above variables upon the cutting speed and of making this study practically useful, may be divided into four sections as follows:

A. The determination by a series of experiments of the important facts or laws connected with the art of cutting metals.

B. The finding of mathematical expressions for these laws which are so simple as to be suited to daily use.

C. The investigation of the limitations and possibilities of metal cutting machines.

D. The development of an instrument (a slide rule) which embodies, on the one hand, the laws of cutting metals, and on the other, the possibilities and limitations of the particular lathe or planer, etc., to which it applies and which can be used by a machinist without mathematical training to quickly indicate in each case the speed and feed which will do the work quickest and best.

How the Investigation was Started and how it has been Carried Along.

In the fall of 1880, the machinists in the small machine shop of the Midvale Steel Company, Philadelphia, most of whom were working on piecework in machining locomotive tires, car axles, and miscellaneous forgings, had combined to do only a certain number of pieces per day on each type of work. The writer, who was the newly appointed foreman of the shop, realized that it was possible for the men to do in all cases much more work per day than they were accomplishing. He found, however, that his efforts to get the men to increase their output were blocked by the fact that his knowledge of just what combination of depth of cut, feed and cutting speed would in each case do the work in the shortest time, was much less accurate than that of the machinists who were combined against him. His conviction that the men were not doing half as much as they should do, however, was so strong that he obtained the permission of the management to make a series of experiments to investigate the laws of cutting metals with a view to obtaining a knowledge at least equal to that of the combined machinists who were under him. He expected that these experiments would last not longer than six months. With the exception of a few comparatively short periods, however, these experiments have continued *until the present time*, through a term of about 26 years.

The writer wishes to call attention to the fact that in these first experiments he was far more fortunate than almost all of the experimenters who have investigated the subject since then, in having at his disposal a comparatively large mass of uniform metal to work upon, and a comparatively large and powerful machine to work with, a 66-inch diameter boring mill and large locomotive tires made of hard tire steel of uniform quality having been used. He was also especially fortunate in having over him as president of the company, Mr. William Sellers, who, as is well known, was one of the most patient and broad-minded experimenters of his day. Mr. Sellers, in spite of the protests which were made against the continuation of this work, allowed the experiments to proceed; even, at first, at a very considerable inconvenience and loss to the shop. The extent of this inconvenience will be appreciated when it is understood that we were using a 66-inch diameter vertical boring mill, belt-driven by the usual cone pulleys, and that in order to regulate the exact cutting speed of the tool, it was necessary to slow down the speed of the engine that drove all of the shafting in the shop; a special adjustable engine governor having been bought for this purpose. For over two years the whole shop was incon-

* Abstract of introduction of paper read before the December, 1906, meeting of the American Society of Mechanical Engineers.
† For biographical sketch, see MACHINERY, January, 1906.

venienced in this way, by having the speed of its main line of shafting greatly varied, not only from day to day but from hour to hour. Before the two years had elapsed, however, the writer had obtained such valuable and unexpected results from the experiments as to much more than justify all of the annoyance and expenditure, and soon after that he readily obtained permission to employ a young technical graduate to devote his whole time to the continuation of this work.

Mr. G. M. Sinclair, a graduate of Stevens Institute of Technology, devoted his entire time to this work from 1884 to 1887, when he left the employ of the company.

Mr. H. L. Gantt, also a graduate of Stevens Institute succeeded Mr. Sinclair in July, 1887, and has been interested with us in carrying on these experiments throughout their whole period.

In 1898 Mr. Maunsel White, of Bethlehem, another graduate of Stevens Institute, joined us and has been actively interested in our work up to this time.

Mr. Carl G. Barth, a graduate of the Technical School of Horten, Norway, joined us in 1899, and is still actively working on our investigations.

Our experiments were continued in the works of the Midvale Steel Company until 1889, when the writer left their employ. Since then, these investigations have been carried on in various shops and at the expense of different companies. Among these, we would especially acknowledge our indebtedness to the Cramp's Shipbuilding Company, Messrs. Wm. Sellers & Co., the Link-Belt Engineering Company, Messrs. Dodge & Day, and, more than all, to the Bethlehem Steel Company.

In carrying on this work more than ten machines have been fitted up at various times with special driving apparatus and the other needed appliances, all machines used since 1894 having been equipped with electric drives, so as to obtain any desired cutting speed. The thoroughness with which the work has been done may perhaps be better appreciated when it is understood that we have made between thirty and fifty thousand recorded experiments, and many others of which no record was kept. In studying these laws we have cut up into chips with our experimental tools more than 800,000 pounds of steel and iron. More than sixteen thousand experiments were recorded in the Bethlehem Steel Company. We estimate that up to date between $150,000 and $200,000 have been spent upon this work, and it is a very great satisfaction to feel that those whose generosity has enabled us to carry on the experiments have received ample return for their money through the increased output and the economy in running their shops which have resulted from our experiments.

Throughout the whole 26 years we have succeeded in keeping almost all of these laws secret, and in fact since 1889 this has been our means of obtaining the money needed to carry on the work. We have never sold any information connected with this art for cash, but we have given to one company after another all of the data and conclusions arrived at through our experiments in consideration for the opportunity of still further continuing our work.

Summary of Discoveries.

The writer has no doubt that many of the discoveries and conclusions which mark the progress of this work have been and are well known to other engineers, and we do not record them with any certainty that we were the first to discover or formulate them, but merely to indicate some of the landmarks in the development of our own experiments, which to us were new and of value. The following is a record of some of our more important steps:

A. In 1881, the discovery that a round-nosed tool could be run under given conditions at a much higher cutting speed and therefore turn out much more work than the old-fashioned diamond-pointed tool.

B. In 1881, the demonstration that, broadly speaking, the use of coarse feeds accompanied by their necessarily slow cutting speeds would do more work than fine feeds with their accompanying high speeds.

C. In 1883, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from the steel forging by the tool, would permit an increase in cutting speed, and, therefore, in the amount of work done of from 30 to 40 per cent. In 1884, a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part; each machine being set in a wrought-iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting), which was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well from which it was pumped to an overhead tank from which a system of supply pipes led to each machine. Up to that time, so far as the writer knows, the use of water for cooling tools was confined to small cans or tanks from which only a minute stream was allowed to trickle upon the tool and the work, more for the purpose of obtaining a water finish on the work than with the object of cooling the tool; and, in fact, these small streams of water are utterly inadequate for the latter purpose. So far as the writer knows, in spite of the fact that the shops of the Midvale Steel Works until recently have been open to the public since 1884 no other shop in this country was similarly fitted up until that of the Bethlehem Steel Company in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Company.

D. In 1883, the completion of a set of experiments with round-nosed tools; first, with varying thicknesses of feed when the depth of the cut was maintained constant; and, second, with varying depths of cut while the feed remained constant, to determine the effect of these two elements on the cutting speed.

E. In 1883, the demonstration of the fact that the longer a tool is called upon to work continuously under pressure of a shaving, the slower must be the cutting speed, and the exact determination of the effect of the duration of the cut upon the cutting speed.

F. In 1883, the development of formulas which gave mathematical expression to the two broad laws above referred to. Fortunately these formulas were of the type capable of logarithmic expression and therefore suited to the gradual mathematical development extending through a long period of years, which resulted in making our slide rules, and solved the whole problem in 1901.

G. In 1883, the experimental determination of the pressure upon the tool required on steel tires to remove cuts on varying depths and thickness of shaving.

H. In 1883, the starting of a set of experiments on belting described in a paper published in the Transactions, A. S. M. E., Vol. 15 (1894).

J. In 1883, the measurement of the power required to feed a round-nosed tool with varying depths of cut and thickness of shaving when cutting a steel tire. This experiment showed that a *very dull tool* required as much pressure to feed it as to drive the cut. This was one of the most important discoveries made by us, and as a result all steel cutting machines purchased since that time by the Midvale Steel Company have been supplied with feeding power equal to their driving power and very greatly in excess of that used on standard machine tools.

K. In 1884, the design of an automatic grinder for grinding tools in lots and the construction of a tool room for storing and issuing tools ready ground to the men.

L. From 1885 to 1889, the making of a series of practical tables for a number of machines in the shops of the Midvale Steel Company, by the aid of which it was possible to give definite tasks each day to the machinists who were running machines, and which resulted in a great increase in their output.

M. In 1886, the demonstration that the thickness of the chip or layer of metal removed by the tool has a much greater effect upon the cutting speed than any other element, and the practical use of this knowledge in making and putting into everyday use in our shops a series of broad-nosed cutting tools which enabled us to run with a coarse feed at as high a speed as had been before attained with round-nosed tools when using a fine feed, thus sustituting, for a considerable portion of the work, *coarse feeds and high speeds* for our old maxim of *coarse feeds and slow speeds.*

N. In 1894 and 1895, the discovery that a greater proportional gain could be made in cutting soft metals through the use of tools made from self-hardening steels than in cutting hard metals, the gain made by the use of self-hardening tools over tempered tools in cutting soft cast-iron being almost 90 per cent, whereas the gain in cutting hard steels or hard cast iron was only about 45 per cent. Up to this time, the use of Mushet and other self-hardening tools had been almost exclusively confined to cutting hard metals, a few tools made of Mushet steel being kept on hand in every shop for special use on hard castings or forgings which could not be cut by the tempered tools. This experiment resulted in substituting self-hardening tools for tempered tools for all "roughing work" throughout the machine shop.

P. In 1894 and 1895, the discovery that in cutting wrought iron or steel a heavy stream of water thrown upon the shaving at the nose of the tool produced a gain in cutting speed of *self-hardening tools* of about 33 per cent. Up to this time the

makers of self-hardening steel had warned users never to use water on the tools.

Q. From 1898 to 1900, the discovery and development of the Taylor-White process of treating tools; namely, the discovery that tools made from chromium-tungsten steels when heated to the melting point would do from two to four times as much work as other tools.

R. In 1899-1902, the development of our slide rules, which are so simple that they enable an ordinary workman to make practical and rapid everyday use in the shop of all the laws and formulas deduced from our experiments.

S. In 1906, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from *cast iron* by the tool would permit an increase in cutting speed, and therefore, in the amount of work done, of 16 per cent.

T. In 1906, the discovery that by adding a small quantity of vanadium to tool steel to be used for making modern high speed chromium-tungsten tools heated to near the melting point, the hardness and endurance of tools, as well as their cutting speeds, are materially improved.

Chief Practical Value of Discoveries Embodied in the Slide Rule.

While many of the results of these experiments are both interesting and valuable, we regard as of by far the greatest value that portion of our experiments and of our mathematical work which has resulted in the development of the slide rules; *i. e.*, the patient investigation and mathematical expression of the exact effect upon the cutting speed of such elements as the shape of the cutting edge of the tool, the thickness of the shaving, the depth of the cut, the quality of the metal being cut and the duration of the cut, etc. This work enables us to fix a daily task with a definite time allowance for each workman who is running a machine tool, and to pay the men a bonus for rapid work.

The gain from these slide rules is far greater than that of all the other improvements combined, because it accomplishes the original object, for which in 1880 the experiments were started; *i. e.*, that of taking the control of the machine shop out of the hands of the many workmen, and placing it completely in the hands of the management, thus superseding "rule of thumb" by scientific control.

Mistakes of Not Originally Determining Each Variable Separately—Standard of Twenty Minutes for Each Test.

Almost the whole course of our experiments is marked by imperfections in our methods, which, as we have realized them, have led us to go again more carefully over the ground previously traveled. These errors may be divided into three principal classes:

A. The adoption of wrong or inadequate standards for measuring the effect of each of the variables upon the cutting speed.

B. Failure on our part from various causes to hold all of the variables constant except the one which was being systematically changed in order to study the effect of these changes upon the cutting speed.

C. The omission either through oversight or carelessness on our part of some one of the precautions which should be taken to insure accuracy, or failure to record some of the phenomena considered unimportant at the time, but which afterward proved to be essential to a complete understanding of the facts.

The effect of each variable upon the problem is best determined by finding the exact rate of cutting speed (say, in feet per minute) which shall cause the tool to be completely ruined after having been run for 20 minutes under uniform conditions. For example, if we wish to investigate the effect which a change in the thickness of the feed has upon the cutting speed, it is necessary to make a number of tools which are in all respects uniform, as to the exact shape of their cutting edge, their clearance and lip angles, their chemical composition and their heat treatment. These tools must then be run one after another, each for a period of 20 minutes, throughout which time the cutting speed is maintained exactly uniform. Each tool should be run at a little faster cutting speed than its predecessor, until that cutting speed has been found which will cause the tool to be completely ruined at the end of 20 minutes (with an allowance of a minute or two each side of the 20-minute mark). In this way that cutting speed is found which corresponds to the particular thickness of shaving which is under investigation.

A change is then made in the thickness of the shaving, and another set of 20-minute runs is made, with a series of similar uniform tools, until the cutting speed corresponding to the new thickness of feed has been determined; and by continuing in this way all of the cutting speeds are found which correspond to the various changes of feed. In the meantime, every precaution must be taken to maintain uniform all the other elements or variables which affect the cutting speed, such as the depth of the cut and the quality of the metal being cut; and the rate of the cutting speed must be frequently tested during each 20-minute run to be sure that it is uniform.

The cutting speeds corresponding to varying feeds are then plotted as points upon a curve, and a mathematical expression is found which represents the law of the effect of feed upon cutting speed. We believe that this standard or method of procedure constitutes the very foundation of successful investigation in this art. It was only after about 14 years' work that we found that the best measure for the value of a tool lay in the exact cutting speed at which it was completely ruined at the end of 20 minutes.

Pressure and Rubbing of Chip what Breaks Down Tool.

The ultimate cause for a tool giving out when cutting metal is the dullness or wear of the tool produced by the rubbing or pressure of the chip upon the lip surface of the tool, and the chief element causing this wear, particularly at the high speeds at which tools should be run to do their best work, is the softening of the tool due to the heat produced by the friction of the chip upon its lip surface. Now, it seems perfectly evident that this heat will be increased directly in proportion to three elements:

a. The pounds of pressure of the chip upon the tool;

b. The speed with which the chip slides across the nose of the tool;

c. The coefficient of friction between the chip and the surface of the tool.

And yet, paradoxical as it may seem, the writer asserts that *there is no traceable relation between the pressure of the chip upon the tool and the cutting speed.*

Discovery of Taylor-White Process.

It is a noteworthy fact that when thorough investigations are attempted by earnest men in new fields, while frequently the object aimed at is not attained, yet quite often discoveries are made which are entirely foreign to the purpose for which the investigation was undertaken. And it may be said that the indirect results of careful scientific work are, generally speaking, fully as valuable as the direct. Two interesting illustrations of this fact have been furnished by our experiments.

The discovery of the Taylor-White process of treating tools by heating them almost to the melting point, or, in other words, the introduction of modern high speed tools the world over, was the indirect result of one of our lines of investigation.

The demonstration of the fact that the rules for using belting in common practice furnished belts which were entirely too light for economy was also one of the indirect results of our experiments.

The manner of making these discoveries was each time in a way so typical of what may be expected in similar cases that it would seem worth while to describe it in some detail.

During the winter of 1894-1895, the writer conducted an investigation in the shop of Wm. Sellers & Co., at the joint expense of Messrs. William Cramp & Sons, shipbuilders, and Messrs. Wm. Sellers & Co., to determine which make of self-hardening tool steel was, on the whole, the best to adopt as standard for all of the roughing tools of these two shops.

As a result of this work, the choice was narrowed down at that time to two makes of tool steel: (1) the celebrated Mushet self-hardening steel, the chemical composition of the particular bar analyzed at this time being as follows:

Tungsten, (per cent) 5.441; chromium, 0.398; carbon, 2.150; manganese, 1.578; silicon, 1.044.

(2) A self-hardening steel made by the Midvale Steel Company of the following chemical composition:

Tungsten, (per cent) 7.723; chromium, 1.830; carbon, 1.143; manganese, 0.180; silicon, 0.246; phosphorus, 0.023; sulphur, 0.008.

Of these two steels, the tools made from the Midvale steel were shown to be capable of running at rather higher cutting

speeds. The writer himself heated hundreds of tools of these makes in the course of his experiments in order to accurately determine the best temperatures for forging and heating them prior to grinding so as to get the best cutting speeds. In these experiments he found that the Mushet steel if overheated crumbled badly when struck even a light blow on the anvil, while the Midvale steel if overheated showed no tendency to crumble, but, on the other hand, was apparently permanently injured. In fact, heating these tools slightly beyond a bright cherry red caused them to permanently fall down in their cutting speeds; and the writer was unable at that time to find any subsequent heat treatment which would restore a tool broken down in this way to its original good condition. This defect in the Midvale tools left us in doubt as to whether the Mushet or the Midvale was, on the whole, the better to adopt as a shop standard.

In the summer of 1898, soon after undertaking the reorganization of the management of the Bethlehem Steel Company, the writer decided to continue the experiments just referred to with a view to ascertaining whether in the meanwhile some better tool steel had not been developed. After testing several additional makes of tools, our experiments indicated that the Midvale self-hardening tools could be run if properly heated at slightly higher speeds than those of any other make.

Upon deciding to adopt this steel as our standard the writer had a number of tools of each make of steel carefully dressed and ground to exactly the same shape. He then called the foremen and superintendents of the machine shops of the Bethlehem Steel Company to the experimental lathe so that they could be convinced by seeing an actual trial of all of the tools that the Midvale steel was, on the whole, the best. In this test, however, the Midvale tools proved to be worse than those of any other make; *i. e.*, they ran at slower cutting speeds. This result was rather humiliating to us as experimenters who had spent several weeks in the investigation.

It was of course the first impression of the writer that these tools had been overheated in the smith shop. Upon careful inquiry among the smiths, however, it seemed as though they had taken special pains to dress them at a low heat, although the matter was left in much doubt. The writer, therefore, determined to make a thorough investigation before finally adopting the Midvale steel as our shop standard to discover, if possible, some heat treatment which would restore Midvale tools injured in their heating (whether they had been underheated or overheated) to their original good condition.

For this purpose Mr. White and the writer started a carefully laid out series of experiments, in which tools were to be heated at temperatures increasing, say, by about 50 degrees all the way from a black heat to the melting point. These tools were then to be ground and run in the experimental lathe upon a uniform forging, so as to find:

a. That heat at which the highest cutting speed could be attained (which our previous experiments had shown to be a cherry red).

b. To accurately determine the exact danger point at which if over or underheated these tools were seriously injured.

c. To find some heat treatment by which injured tools could be restored to their former high cutting speeds.

These experiments corroborated our Cramp-Sellers experiments, showing that the tools were seriously broken down or injured by overheating, say, somewhere between 1,550 degrees F. and 1,700 degrees F.; but to our great surprise, tools heated up to or above the high heat of 1,725 degrees F. proved better than any of those heated to the best previous temperature, namely, a bright cherry red; and from 1,725 degrees F. up to the incipient point of fusion of the tools, the higher they were heated, the higher the cutting speeds at which they would run.

Thus, the discovery that phenomenal results could be obtained by heating tools close to the melting point, which was so completely revolutionary and directly the opposite of all previous heat treatment of tools, was the indirect result of an accurate scientific effort to investigate as to which brand of tool steel was, on the whole, the best to adopt as a shop standard; neither Mr. White nor the writer having the slightest idea that overheating beyond the bright cherry red would do anything except injure the tool more and more the higher it was heated.

Ordinary Belting Too Light.

During our early Midvale Steel Company experiments, extending from 1880 to 1883, the writer had so much trouble in maintaining the tension of the belt used in driving the boring mill upon which he was experimenting that he concluded: (1) that belting rules in common use furnished belts entirely too light for economy; and (2) that the proper way to take care of belting was to have each belt in a shop tightened at regular intervals with belt clamps especially fitted with spring balances, with which the tension of the belt was accurately weighed every time it was tightened, each belt being retightened each time to exactly the same tension.

In 1884, the writer designed and superintended the erection of a new machine shop for the Midvale Steel Company, and this gave him the opportunity to put these conclusions to a practical test. About half the belts in the shop were designed according to the ordinary rules and the other half were made about three times as heavy as the usual standard. This shop ran day and night. The belts were in all cases cared for and retightened only upon written orders sent from the shop office; and an accurate record was kept through nine years of all items of interest concerning each belt, namely: the number of hours lost through interruption to manufacture; the number of times each belt interrupted manufacture; the original cost of each belt; the detail costs of tightening, cleaning and repairing each belt; the fall in the tension before requiring retightening; and the time each belt would run without being retightened. Thus at the end of nine years these belts furnished a record which demonstrated beyond question many important facts connected with the use of belting, the principal of these being that the ordinary rules gave belts only about one-half as heavy as should be used for economy. This belting experiment illustrates again the good that often comes indirectly from experiments undertaken in an entirely different field.

Need of Standardization.

Too much emphasis cannot be laid upon the fact that standardization really means simplification. It is far simpler to have in a standardized shop two makes of tool steel than to have 20 makes of tool steel, as will be found in shops under the old style of management. It is far simpler to have all of the tools in a standardized shop ground by one man to a few simple but rigidly maintained shapes than to have, as is usual in the old-style shop, each machinist spend a portion of each day at the grindstone, grinding his tools with radically wrong curves and cutting angles, merely because bad shapes are easier to grind than good. Hundreds of similar illustrations could be given showing the true simplicity (not complication) which accompanies the new type of management.

No one doubts for one minute that it is far simpler to run a shop with a boiler, steam engine, shafting, pulleys and belts than it would be to run the same shop with the old-fashioned foot power, yet the boiler, steam engine, shafting, pulleys and belts require, as supernumeraries or non-producers on the payroll, a fireman, an engineer, an oiler, and often a man to look after belts. The old style manager, however, who judges of complication only by comparing the number of non-producers with that of the producers, would find the steam engine merely a complication in management. The same man, to be logical, would find the whole drafting force of an engineering establishment merely a complication, whereas in fact it is a great simplification over the old method.

Individual Motor Drive Not Recommended.

There is one recommendation, however, in modern machine shop practice in making which the writer will probably be accused of being old-fashioned or ultra-conservative. Of late years there has been what may be almost termed a blind rush on the part of those who have wished to increase the efficiency of their shops toward driving each individual machine with an independent motor. The writer is firmly convinced through large personal observation in many shops and through having himself systematized two electrical works that in perhaps three cases out of four a properly designed belt drive is preferable to the individual motor drive for machine tools. There is no question that through a term of years the total cost, on the one hand, of individual motors and electrical wiring, cou-

pled with the maintenance and repairs, of this system will far exceed the first cost of properly designed shafting and belting plus maintenance and repairs (in most shops entirely too light belts and countershafts of inferior design are used, and the belts are not systematically cared for by one trained man, and this involves a heavy cost for maintenance). There is no question, therefore, that in many cases the motor drive means in the end additional complication and expense rather than simplicity and economy.

* * *

FORMULAS FOR DETERMINING THE PROPORTIONS OF TAPS.

ERIK OBERG.

It has been a very common thing among manufacturers of taps, and still more among persons who only occasionally have been called upon to make these tools, to produce taps without following any definite rule as to the proportions of the various details. Little attention has been given to the possibility of expressing the relation between the diameter and the total length, for instance, by a simple formula. For this reason it is very common to find that the dimensions of taps, or of any other tools of a similar character which are made in a great number of sizes, do not follow any definite rule in their proportions, except the one that a larger size has most of its dimensions a trifle larger than those of the preceding one; even this, however, is not always the case as persons familiar with small tools cannot have helped but notice. Various manufacturers also differ widely as to the proportions of their tools. For this reason the writer has made an attempt to express the rules according to which taps of proper proportions could be made in simple formulas. These formulas are all worked out so that all the dimensions of the tap stand in a certain relation to the diameter of the tap. This insures a tap which will be well proportioned and at the same time it will be well adapted for its work, even if the pitch of the thread should vary for the same diameter. The formulas are worked out with particular regard to taps with standard threads, either United States standard or sharp V-thread, but will be equally serviceable for finer pitches.

Hand Taps.

If we first consider the case of ordinary hand taps, we will find that it is not possible to get a set of formulas which will be suitable for all sizes from the very smallest to the very largest. For this reason we must work out one set of formulas which will be adapted for sizes up to and including one inch in diameter, and one set for larger sizes. In the formulas:

A = the total length of the tap,
B = the length of the thread,
C = the length of the shank,
D = the diameter of the tap,
E = the diameter of the shank,
F = the size of the square,
G = the length of the square.

For sizes up to and including one inch in diameter our formulas are:

$A = 3.5D + 1\frac{5}{8}$ inch,
$B = 2D + \frac{1}{2}$ inch,
$C = 1.5D + 1\frac{1}{8}$ inch,
E = root diameter of thread — 0.01 inch,
$F = 0.75E$,
$G = 0.75D + 1/16$ inch.

For sizes one inch and larger our formulas will be:

$A = 2.25D + 2\frac{7}{8}$ inches,
$B = D + 1\frac{1}{2}$ inch,
$C = 1.25D + 1\frac{3}{4}$ inch,
E = root diameter of thread — 0.02 inch,
$F = 0.75E$,
$G = 0.33D + \frac{1}{2}$ inch.

The supplement contains tables for the dimensions of hand taps with standard threads based on these formulas. Of course, where no necessity for close fractional dimensions exists, the dimensions are only approximately those obtained from the formulas, and are given as practical working dimensions. As seen in the table the shanks for the 3/16 inch and the ¼ inch diameter taps are made equal to the diameter of the tap, according to the usual custom in manufacturing these taps.

Machine Screw Taps.

We will next give formulas for taps used for tapping the holes for regular machine screws, these taps being termed machine screw taps. In fact these taps are nothing but hand taps, but it has become customary to make them in a somewhat different way from ordinary hand taps. The shank on the smaller sizes is larger than the diameter of the tap itself, and on the larger sizes equal to the diameter of the tap. On the larger sizes there is a neck between the threaded portion and the shank, but on the smaller the thread runs directly into the shank part. In the formulas for machine screw taps:

A = the total length of the tap,
B = the length of the thread,
C = the length of the neck,
D = the diameter of the tap,
E = the length of the shank,
F = the diameter of the shank,
G = the size of the square,
H = the length of the square.

The following formulas will apply to all sizes of machine screw taps:

$A = 5D + 1\ 5/16$ inch;
$B = 3D + \frac{3}{8}$ inch,
$G = 0.75F$,
$H = 0.67D + \frac{1}{8}$ inch.

F, the diameter of the shank, is 0.125 inch up to and including No. 5 machine screw tap, and equal to D for larger sizes. Up to and including No. 7 machine screw tap there is no neck between the shank and the thread. For larger sizes

$C = 0.75D$.

For sizes up to and including No. 7

$E = 2D + 15/16$ inch.

For larger sizes

$E = 1.25D + 15/16$ inch.

The supplements contain a table based upon these formulas.

Tapper Taps.

For tapper taps we may also make up a set of empirical formulas. In these

A = the length of the thread,
B = the parallel part of the thread,
C = the chamfered part of the thread,
D = the diameter of the tap,
E = the diameter of the shank,
F = the diameter at the point of the thread.

The formulas for tapper taps up to and including 9-16 inch are as follows:

$A = 4.5D + 5/16$ inch,
$B = 2.75D + 3/16$ inch,
$C = 1.75D + \frac{1}{8}$ inch,
E = root diameter of thread — 0.01 inch,
F = root diameter of thread — $(0.005D + 0.005$ inch).

For sizes from ⅝ inch diameter to 2 inches inclusive the formulas are:

$A = 2D + 1\frac{3}{4}$ inch,
$B = 1.25D + 1$ inch,
$C = 0.75D + \frac{3}{4}$ inch,
E = root diameter of thread — 0.02 inch,
F = root diameter of thread — $(0.005D + 0.005$ inch).

By means of the formulas given, the dimensions for any intermediate size between those tabulated in the supplement may easily be determined. It is understood, of course, that the formulas have a great degree of flexibility, and that they are proposed only in order to facilitate the work of the toolmaker or draftsman to whom it is often left to settle upon the dimensions for these tools. The tables (see supplement) are worked out in order to save figuring in each individual case, but, as stated previously, give the approximate working dimensions, and do not give the close theoretical values figured from the formulas, excepting when essential.

* * *

The total railway mileage under contract for construction or in immediate prospect in the United States and Canada is over 25,000 miles.

THE PLANER VS. THE MILLING MACHINE.

H. P. FAIRFIELD.

It did not occur to me when presenting the photographs of a simple planer job in the September, 1906, issue that the editorial comment would bring out an opinion regarding the relative value, as a cost reducer, of planing and milling. The remarks as I read them, are of a general nature, and were meant to apply to grouped or strung work as it is usually done on the planer, and the particular piece shown was merely used to give point to the words.

The question of planing *versus* milling is to me an interesting one, and Mr. Edgar's presentation of his views in the November issue has interested me to the extent of showing a few more photographs, illustrating the manner in which work is being done by several of our New England firms of high standing, who have given time and thought to the subject of costs in the shop.

It may be well to mention that the object of the original illustrations was to show a simple job of planer work and the way in which it could be systematically done in a planer where only the regular equipment of the machine was available, that is to say, the usual stops, straps, bolts, leveling strips, backing strips and chucks. The piece shown is regularly done in our shops, using special fixtures, but as these might vary in different shops they were not pertinent to the purposes which were sought in the original paper.

Fig. 1 of the present paper illustrates the fixture we use

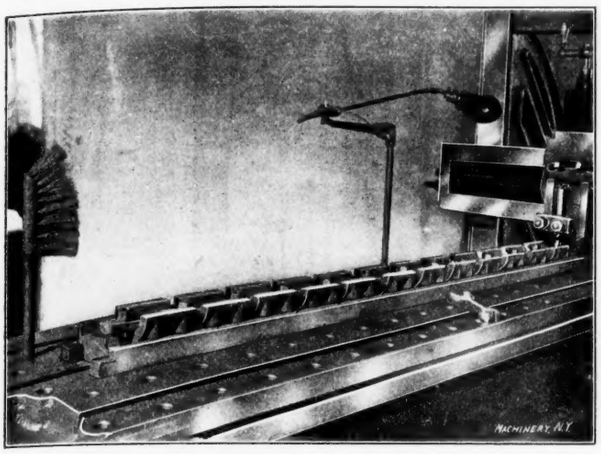


Fig. 1. Fixture for Holding Caps for Bearings while Planing.

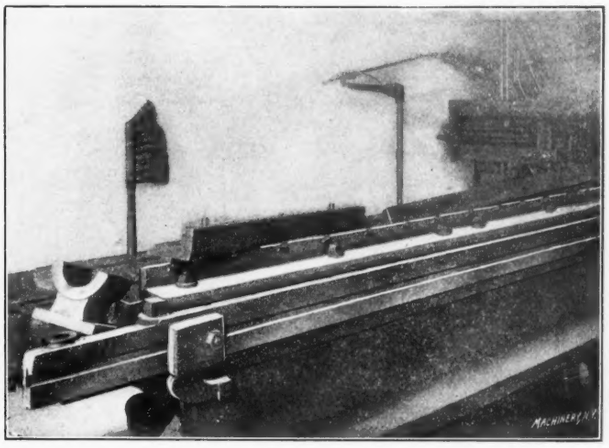


Fig. 2. Fixture for Holding Base of Bearings while Planing.

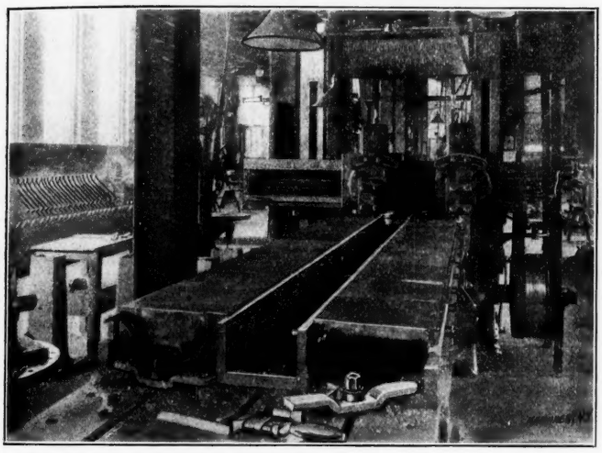


Fig. 3. Fixture for Planing Castings shown in Fig. 4.

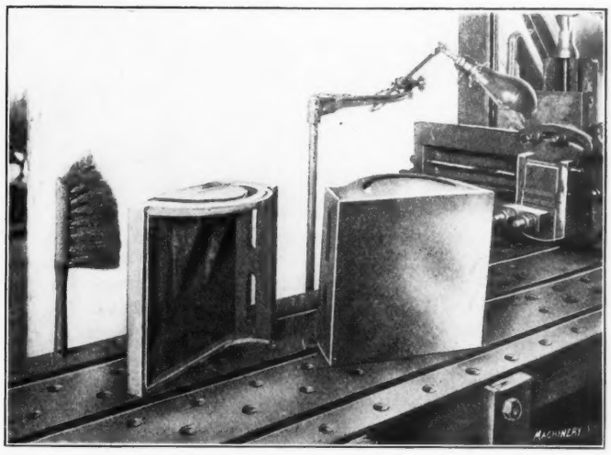


Fig. 4. Castings Planed in Manner shown in Fig. 3.

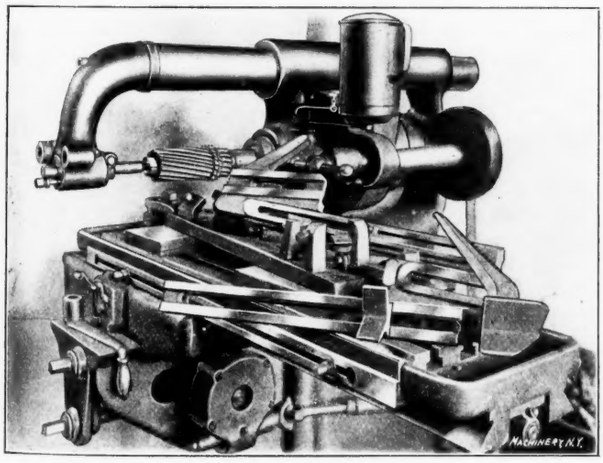


Fig. 5. Work on which the Milling Machine is Superior to the Planer.

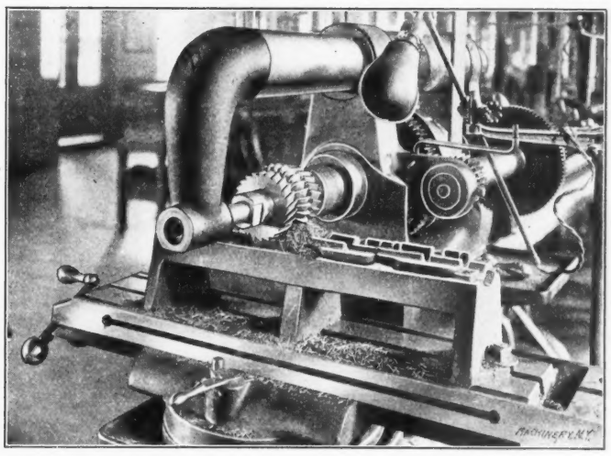


Fig. 6. Using Gang of Cutters for Rapid Finishing by Milling.

for holding the caps, and it appears to me as being much simpler than the one Mr. Edgar suggests as there are no pins or setscrews, a simple casting fitted to the planer bed comprising all there is to it.

Fig. 2 shows the fixtures used in holding the base portion of the bracket, and they will be seen to consist of a simple backing strip, undercut at the lower edge to lock the edge of the casting, and a similar strip for the front side of the

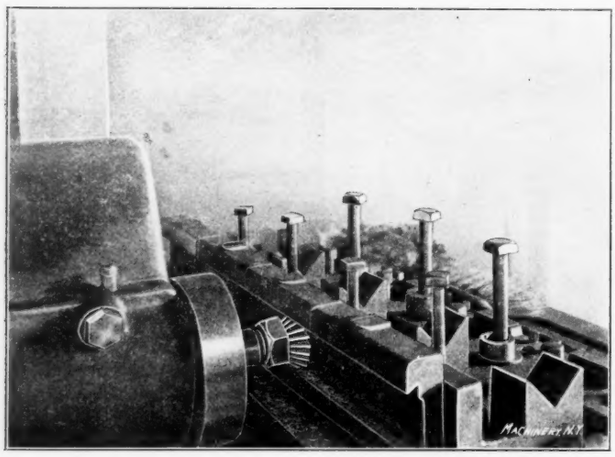


Fig. 7. Finishing Slides by Angular Cutter on the Milling Machine.

planer, fitted with setscrews at an angle suitable for forcing the casting to be held against the backing strip and down firmly to the planer platen. For ease of handling, these strips are made in short sections, but when in use they form a continuous fixture and can be used in sets, if there is more than one head mounted upon the cross-rail. This fixture, while similar to the one shown by Mr. Edgar is to my mind simpler, as no setscrews are used, or needed, in the backing. His jig or fixture for holding the piece when milling with a face cutter *might* hold the work when a light cut was being taken, but could hardly be said to be a good device as it appears trappy and locates by the wrong surfaces to insure steadiness.

Fig. 3 shows a set of fixtures designed to hold the casting shown in Fig. 4 while it is being planed. As the planer used for this work has two heads upon the cross-rail the castings are strung in two groups covering practically the whole surface of the platen.

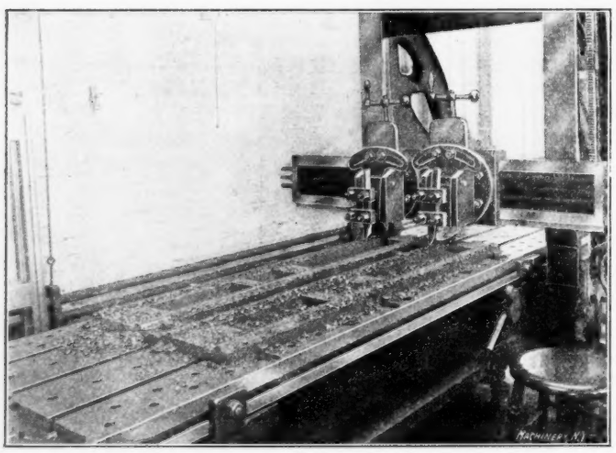


Fig. 8. A Case where Accuracy is Easier Procured by using the Planer.

A decision as to whether a piece of work shall be done upon a milling machine or in a planer often depends upon the available machine, but in our shop much experimenting has been and is being done in an honest attempt to learn which method will give the lowest piece cost. The mere question of removing stock is only a portion of the problem; the relative expense of equipment enters to some extent, but the main question in determining the method of machining is that condition of the work when leaving the different machines which calls for the least hand work to insure both accuracy and finish. An ability to chew cast iron does not mean much after all in machine construction unless other qualifications are present.

The result of experiment has led to milling some work that was formerly planed, but so far as our results show there is not much comparison between the two methods for the work shown, when time, accuracy, and low initial cost are considered. An attempt has also been made to add others' experiences to our stock of data, and considerable time has been spent in viewing what the other fellow has done. The results of all this lead us to conclude that for simple plane surfaces, the planer properly equipped with fixtures and tools by which to do the work is in the game to stay.

When such work as that shown in Fig. 5 has to be done in any considerable quantities, the milling machine will naturally be the method chosen. Fig. 6 shows another job that can be done upon an ordinary milling machine, and much quicker than on the planer. In Fig. 7 experiment has led to milling the angled side of the piece, but the reverse, which is a simple plane surface, is done upon a planer, stringing as many as convenient at a time. Figs. 8 and 9 are views that show ordinary practice, and when accuracy and piece cost is an item, in my opinion the *best* practice.

To sum up, then, my belief is that where the simpler plane surfaces that naturally lend themselves to grouping, are to be produced, the planer with a proper equipment is the natural machine to use, and will be found to give the lowest piece

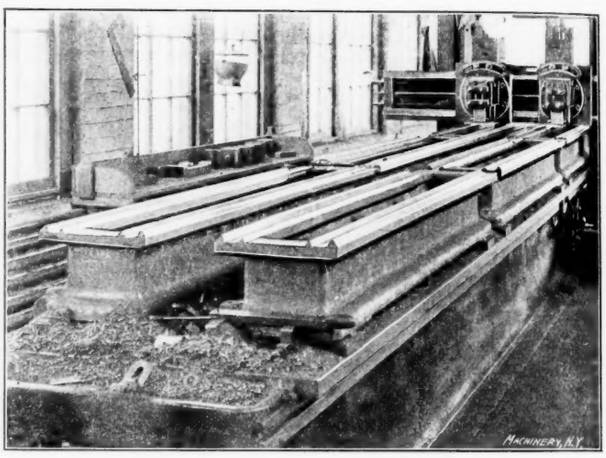


Fig. 9. Planing the Ways of Lathe Beds.

cost. It is understood, of course, that the piece cost when figured includes its proportionate share of fixed costs as it always should.

* * *

THE SIXTIETH BIRTHDAY OF BUGHOUSE BANNISTER.

THE HIRED MAN.

Bughouse Bannister was a millwright; if he had been twenty-five or thirty years old, instead of sixty, he would have been a mechanical engineer or a mechanical superintendent, or a master mechanic or a mechanical expert, but being sixty, he refused to call himself any new-fangled name.

The ambition of his life had been to bring forth a new steam engine, one that would astonish his friends, and now on his sixtieth birthday the engine was done and ready to try, and Bughouse invited his friends in to be astonished, and they certainly were astonished good and plenty! * * *

Just as firmly as Bughouse stuck to his title of millwright, he also stuck to some ideas of millwright vintage; he could not realize that mechanical art had improved to the extent that it was possible to make gears good enough so that a rack and pinion feed could be used in a machine without "the teeth showing the work," or that bevel gears could be made to run as well and be as good every way as spur gears, and so he naturally clung also to the old idea of millwright days, that one gear of a pair must have a "hunting tooth." Thus do some people refuse to be "dragged from the altars

of their forefathers," and thus was Bughouse put in a position to astonish his friends. * * * * *

It never was quite clear to me why Bughouse clung so tenaciously to the old exploded ideas, but it may be because he was over "fifty." I was told not long ago by a gentleman who is an eminent authority on *some* subjects, from which *some* people, including Bughouse, would argue that he must necessarily be also an eminent authority on *all other* subjects, that "men over fifty do not progress," but here is what is puzzling me: this eminent authority is himself "over fifty," and if he is right, men "over fifty" do *not* progress, and if they don't, *he*, being "over fifty" must be *wrong*: therefore men over fifty *do* progress, and it follows that—well, anyhow, it is evident that it is a perplexing subject, and the more you study it the more you don't find out, but all this is neither yonder nor here, as Bughouse used to call the New York & New Haven Railroad. * * * *

Bughouse started up his engine. She turned over nicely a few times, and then began to hesitate a little going by the quarter. Then instead of going by she stopped just before she got there, and came back the other way almost to the quarter, then back again, but not so near to the quarter this time, and so on, less and less, until she reversed the whole thing and started up the other way and finally made a few turns backwards.

Bughouse always said that when he made his engine he would drive the valve by gears, *because gears had more power*

"You must have a hunting tooth."

than *anything else* (and I have heard truly mechanical engineers say the same about gears)—so he did as he always said he would do, *and had put a "hunting tooth" in one of the gears.* * * * * * *

These peculiar motions, while they might be all right for a washing machine or a cock grinder, were no good for an engine; and this is about the way some things are "invented." A man tries to invent a peanut roaster, and when he gets it done finds it will make a much better ice cream freezer, and so calls the world to witness what a great ice cream freezer inventor he is!

I know, because I am an inventor myself.

* * * * * *

This is the first story I have ever written where the moral could not easily be seen without the aid of X-rays, but the moral of this one does not seem to be clear, probably because I am myself "over fifty," so I will need to add the only moral I can think of: *Don't have any birthdays after you are forty-nine.*"

* * *

About 35,000 American automobiles were manufactured in 1906 and it is expected that this number will be greatly exceeded in 1907, it being estimated that 45,000 cars will be manufactured to supply the enormous demand.

PERSPECTIVE VS. OBLIQUE PROJECTIONS.

FREDERIC R. HONEY.

Frederic R. Honey.

When the study of linear perspective is omitted in a course of instruction in industrial drawing, it is for the reason that it is dispensable in practical work. A knowledge of perspective is essential to the artist, however, because his work always includes the representation of objects as they appear, as distinguished from their representation in their true dimensions, which is specifically the province of the mechanical draftsman. Then, again, a knowledge of perspective is regarded as involving a considerable familiarity with complicated constructions which have no direct bearing on the work of the draftsman.

As a consequence, when it becomes necessary to represent an object pictorially, to convey to the ordinary observer a knowledge of its general form and proportions, one of the systems of oblique or of isometric projection is employed. This kind of projection is frequently introduced in drawings accompanying the specifications of patents but gives a more or less distorted view of the object.

The principle of the oblique projection is illustrated in Fig. 1. Let *abcd* represent a plane or a sheet of drawing paper. Let *E F* be a perpendicular line piercing the plane at *F*. If any oblique line be drawn from *E* to this plane, piercing it at *e*, e_1, e_2 or e_3, and this point be joined with *F*, any one of the lines *F e*, *F* e_1, *F* e_2 or *F* e_3 is an oblique projection of *E F*. The line *E e*, *E* e_1, *E* e_2 or *E* e_3 may be situated in any direction, and may form any assigned angle with the plane. That is, a perpendicular line may be represented in any direction, and may be made as long or as short as we please.

A very convenient system, and the one which the writer usually adopts, is the following: From Fig. 1 we see that all lines situated in the plane of the paper are shown in their true length and relative positions. The same is true of all lines in any plane parallel to the plane of the paper.

If we draw all lines which are perpendicular to the paper, at an angle of 45 degrees, and make them one-half of their length in space, we obtain a very simple and easily recognized representation of the object.

Let the square *abcd*, Fig. 2, represent a face of a cube in coincidence with the plane of the paper. Draw the 45-degree lines, *ae*, *bf*, *cg* and *dh*, each equal to one-half the edge of the cube, and complete the square *efgh*. The face of the cube which coincides with, and the one which is parallel to the plane of the paper, are shown in their true value.

The same will evidently be true of the cylinder, Fig. 3, as one base coincides with the paper. The 45-degree line *ab* drawn from the center *a* making *ab* equal to one-half the length of the cylinder, determines the center of the base parallel to the paper; and the figure is completed by the 45-degree lines tangent to the circles.

If we wish to represent a hollow cylinder or tube, the thickness of the material is shown in its true dimensions, and the circles described from *a* and *b* as centers complete the projection. If these figures be drawn on a large scale, the distortion would be very marked and the superiority of the perspective drawings, Figs. 4 and 5, is apparent.

Let the square *abcd*, Fig. 4, represent one face of the cube. Assume *S* any convenient point above the cube, and draw *SD* parallel to *ab*, making it equal to the distance from the eye of the observer to the paper. This measurement will fall beyond the limits of the paper as indicated by the arrow. We assume for the moment that it is accessible.

FREDERICK R. HONEY was born in London, England. He was a student at the school of Science and Art, South Kensington, London, and served an apprenticeship with Ravenhill & Co., marine engineers, London. At one time he had a position under the British Government at the Bombay Dock Yard, East Indies, and was afterward chief engineer of a steamer owned by a Parsee firm plying on the west coast of India. He is an instructor in the Sheffield Scientific School, and lecturer in the Yale School of Fine Arts and in the Art School, Smith College. Mr. Honey has been a well-known contributor to various technical publications for many years.

From a, b, c and d draw lines to S. Produce dc to c making $ce = cd$. From e draw a line to D (off the paper), intersecting cS at f. Draw the perpendicular fg and the horizontal gh, completing the perspective of the solid which is a correct perspective drawing, and which will satisfy the eye if it be placed at a distance from the paper equal to the measurement SD.

In order to bring the construction wholly within the limits of the drawing, we may mark on the line drawn from S any fractional part of the distance to D, as for example, one-fourth to $\frac{D}{4}$. If we lay off ck one-fourth of dc and draw a line from k to $\frac{D}{4}$ we obtain f, the same intersection as before. Any fraction of the distance may be laid off on SD provided the same fraction is employed on dc produced.

The height of the horizon or the level of the eye is assumed by the draftsman. S represents the point opposite the eye, or its projection on the paper. Its distance on the right or the left of the object is also assumed. These measurements evidently affect the apparent outline of the figure. They are selected at distances calculated to produce a satisfactory perspective drawing, *i. e.*, one which will exhibit the required details clearly. The draftsman should be careful not to make the distance from S to D too short, which would result in "steep perspective."

The application of the construction in drawing a cylinder, Fig. 5, is very simple. From o, the center of the circle, draw the horizontal line oa equal to one-fourth of the length of the cylinder.

A line drawn from a to $\frac{D}{4}$ intersects oS at b, the center of the other base. Draw bd parallel to oa. A line drawn from c to S intersects bd at d. With the radius bd draw the circle representing the other base. Tangents to the two circles drawn to S complete the outline of the figure. The drawing is completed by the circles representing the hole, the radii of which are, respectively, oe and bf.

To illustrate the use to which perspective may be put in practical work, and to indicate the superiority of this method of representing an object as compared with oblique projection, we take as an example a portion of a built-up crankshaft such as is used in the most powerful reciprocating engines of our large steamships. The proportions in Figs. 6 and 7 showing two views of the crankshaft are in accordance with the best practice, and are taken from "Machine Design," by Low and Bevis. Fig. 8 is an oblique projection reduced to an assigned scale. The distance between the axes of the shaft and pin are laid off on a perpendicular from a to b. From each of these points 45-degree lines are drawn on which are laid off one-half of the measurement corresponding to those which are found in Fig. 7.

Thus $ac = bd$ = one-half of AC; $ce = df$ = one-half of CE; and $eg = fh$ = one-half of EG. From each of the centers a, c, e and g, draw two circles whose diameters are equal to kl and mn, Fig. 6. From each of the centers b, d, f and h, draw two circles whose diameters are equal to pq and rs. Connect the eye of the crankpin with that of the shaft by arcs which correspond with those of Fig. 6. The outline of Fig. 6 is repeated four times, and then 45-degree tangents showing visible lines, are drawn completing the oblique projection.

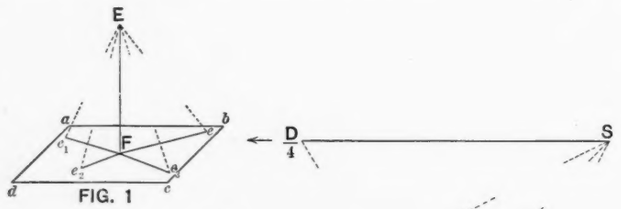


FIG. 1

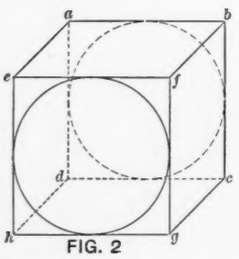


FIG. 2

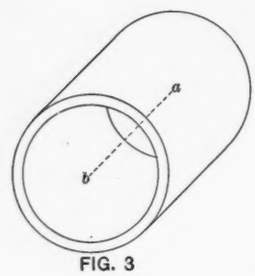


FIG. 3

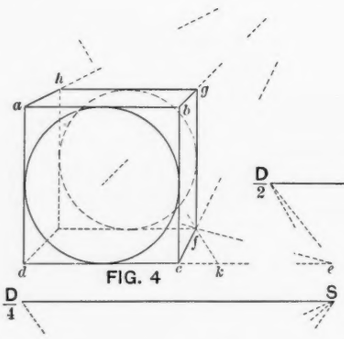


FIG. 4

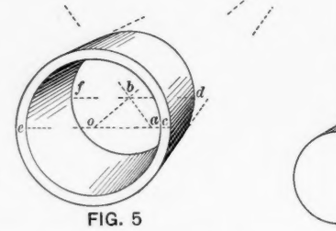


FIG. 5

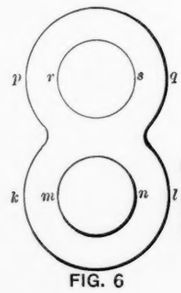


FIG. 6

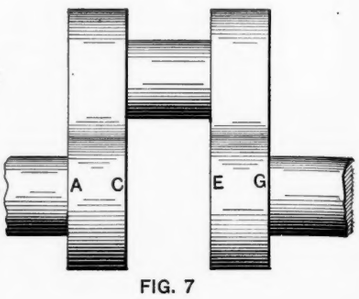


FIG. 7

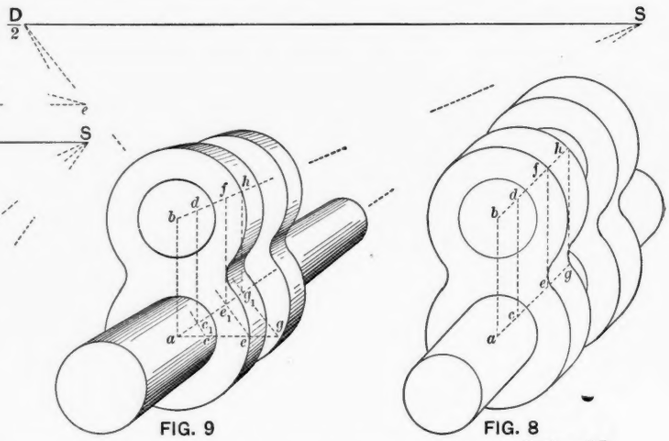


FIG. 9

FIG. 8

Machinery, N. Y.

Principles and Practice of Perspective Drawing. Note the Distortion in Oblique Projections.

The perspective, Fig. 9, is drawn as follows: Draw the perpendicular ab equal to the distance between the centers of the circles, Fig. 6, and copy the end view. Assume a horizontal line S $\frac{D}{2}$ equal to one-half the distance from the eye to the paper, at any convenient distance above the figure. From a and b draw lines to S. From a draw the horizontal line ag, and lay off $ac = \frac{AC}{2}$ (Fig. 7); $ce = \frac{CE}{2}$, and $eg = \frac{EG}{2}$. From the points c, e and g draw lines to $\frac{D}{2}$, intersecting aS at c_1, e_1 and g_1. From these points draw perpendiculars intersecting bs at d, f and h. From S draw tangents to the circles representing the eyes of the pin and shaft. Perpendiculars from d, f and h drawn to one tangent; and perpendiculars from c_1, e_1 and g_1 to the other tangent, will give the radii of the remaining circles, and the draftsman will readily complete the perspective.

LETTERS UPON PRACTICAL SUBJECTS.

ANCHOR PLATES FOR FOUNDATION BOLTS.

I show herewith sketches of two styles of anchor plates. At the shop where I am employed we had been using the anchor plate shown in Fig. 1 with a square head bolt. We had to rearrange our machinery, placing much of it upon new foundations, and rather than dig out the old plates and bolts we sawed the bolts off with a hack-saw even with the floor line.

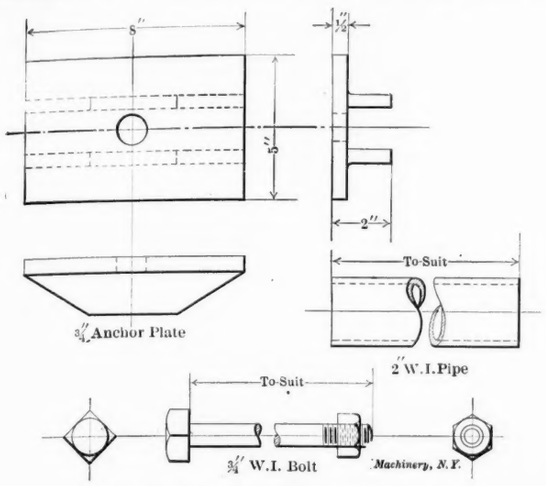


Fig. 1. Old Style Anchor Plate for Square Head Bolt.

In setting up the new foundations the bolts would in some cases be too long and in places too short after the floor was leveled. To overcome this difficulty the bolt and plate shown in Fig. 2 were designed. With this bolt a square nut is set on the little shelf, shown by the section lining, where the projecting ledge at each side holds it in place. A straight rod threaded on both ends is screwed into it. The ring on top of the plate keeps the pipe centered around the bolt while the cement or grouting is being poured. When the bolt is short all that is necessary to do is to cut off a new rod of the required length, thread it, and place it in the pipe, where it may be screwed into the nut, which is so securely enclosed that it cannot be lost. When the machinery is moved the bolt can be taken out and used in the new foundation. E. C. F.

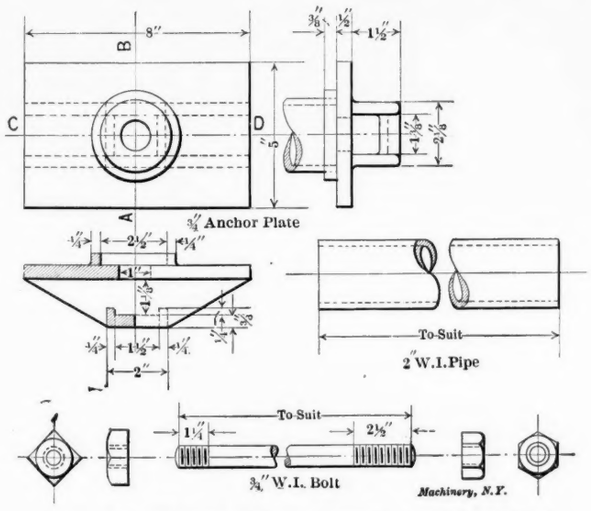


Fig. 2. Improved Anchor Plate for Square Nut and Threaded Rod.

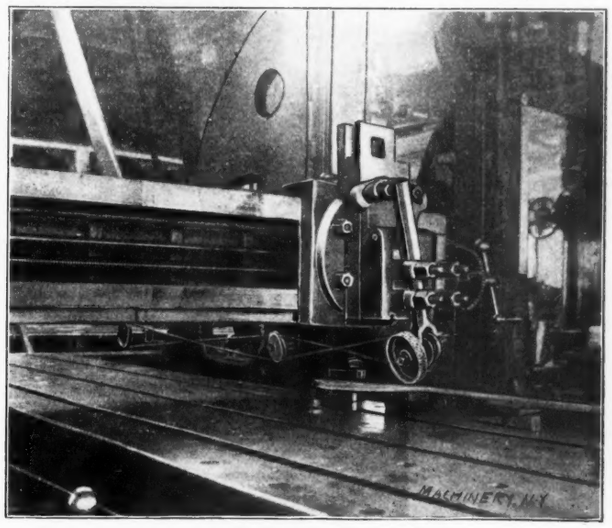
THE PROPER METHOD OF MAKING SURFACE PLATES.

In order to have straight and true beds and platens on the machine tools manufactured to-day, it is essential to have good surface plates to scrape them in by. There has long existed an erroneous idea as to how to make a good surface plate. Some contend that a good proof staff or surface plate can be made by scraping in two plates together, until they show a good bearing. This is not right. A proof staff made after such a fashion is not necessarily true. Inaccuracies in the one plate will often be concealed by corresponding inaccuracies in the other. The proper way to obtain a good surface plate or proof staff is to have three plates carefully planed up and then worked with as follows, numbering the plates one, two and three. First, fit No. 3 and No. 2 to No. 1; you have now No. 2 and No. 3 alike; second, fit No. 2 and No. 3 by scraping as much on one plate as the other; third, fit again No. 1 to No. 2; fourth, fit again No. 3 to No. 1; fifth, fit No. 2 to No. 3 together by scraping as much on one plate as the other. Continue this procedure carefully until No. 1 will fit No. 2 and No. 3, and No. 2 will fit No. 1 and No. 3. You have now three plates that are accurate and which can be relied upon. Having three good plates, one can be laid aside as a guide to be used only for testing the other plates at frequent intervals, while the other plates can be used in active service.

J. J. JENKINS.

SURFACE GRINDING ON THE PLANER.

The accompanying cut shows a surface-grinding job done on the planer. The work seen strapped on the bed is one jaw of the guide for an endless steel knife, which runs over pulleys exactly as does a band saw, and is kept perfectly straight on the tangents by these guides. The latter are made of cast iron, faced with hardened steel, and have to be trued up every few months because of the constant motion of the knife. To do this with a tool was out of the question, so our foreman, Mr. S. F. Cronk, solved the problem with the outfit shown, constructed entirely from odds and ends. In the toolpost of the planer is secured the shank of the holder for a small grinding wheel spindle and on the rear of the housing is clamped a jack-shaft having a grooved pulley at one end and a flanged pulley at the other. This shaft is driven by a one-inch belt, which can be seen inside the reverse belt and which passes over the large pulley on the countershaft. The round belt shown under the cross-rail drives the grinding wheel spindle from the jack-shaft. The cutting is done by the body of the cup-shaped wheels which have served their usefulness on the cutter grinder. As can be seen, the photograph was taken about on the level of the planer bed, the machine itself being a 15-foot New Haven planer with clutch drive.



Surface Grinding on the Planer.

Middletown, N. Y. DONALD A. HAMPSON.

ANOTHER MATHEMATICAL "PROOF."

Having realized that my attempt to disprove Euclid was met with stern opposition, and that the readers of MACHINERY bestowed upon me ridicule rather than compassion, which lat-

ter would probably have been a more properly selected sentiment in the case, I have promised myself not to try to aspire to scientific honors in the realms of geometry; this, however, does not say that I am going to "give up," but simply that I intend to switch over to a more congenial territory. The laws of geometry are evidently a little too rigid to be tampered with; but by means of algebra one can prove almost anything. While the readers of MACHINERY did not favorably accept of my "proof" that a right angle equals one that is larger than a right angle, there may be some difference of opinion as to the fundamental principles of algebra if I can prove that 1 equals 2 by the use of simple algebraic operations. Assume that

$$a = b.$$

Multiply both terms with a, in which case

$$a^2 = ab.$$

Subtract from both terms b^2. The remainders are then equal:

$$a^2 - b^2 = ab - b^2.$$

This expression can be written in the form

$$(a + b)\ (a - b) = b(a - b).$$

Divide both members with $a - b$; the quotients are then equal:

$$\frac{(a + b)\ (a - b)}{a - b} = \frac{b(a - b)}{a - b}.$$

Carrying out the division we have

$$a + b = b.$$

But a is assumed equal to b. Thus

$$b + b = b, \text{ or } 2b = b.$$

Divide both terms with b and we have

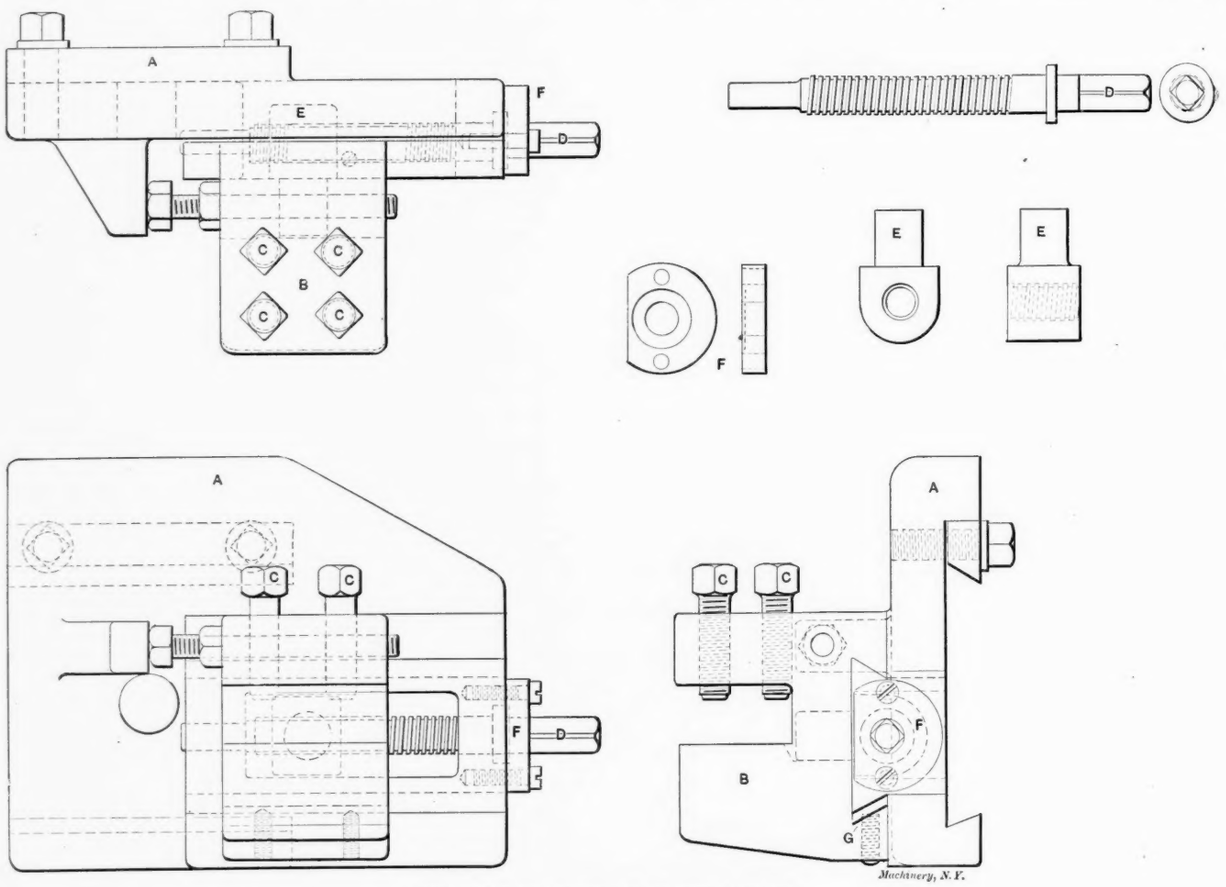
$$2 = 1.$$

Whoever invented the algebraic operations made use of is not known, but the honor is supposed to belong to an Arab whose name is not preserved to posterity. Perhaps that makes it safer to question his methods than in the case of Euclid. I promise I shall never attack his conclusions any more. But, by the way, I have a scheme of perpetual motion which is not yet patented. Any person with sufficient capital for exploration may have it for the asking. R. S.

TOOL HOLDER FOR CHUCKING IN THE SCREW MACHINE.

The accompanying cut shows a tool used in connection with chucking work on a 2-inch screw machine designed for machining round bar stock only. On this machine, when it was necessary to use a chuck to hold pieces, the cross-slide of the machine was thrown out of service, both on account of the large swing of the chuck body and the short length of the longitudinal feed screw of the machine. Moreover, the capacity of the regular box tools in the turret was but 2¼ inches. For these reasons the following fixture was designed.

Referring to the cut, *A* represents a steel casting which fits on the turret of the machine. The tool carrier, *B*, which is a steel forging, finished all over, is provided with four set-screws, *C*, and receives its feed from the square-threaded screw *D*, which in turn is operated by an ordinary crank. By using four clamping screws for holding the tools, it becomes possible to do both end and side forming, facing and turning. The feed screw *D* is a running fit in the bronze nut *E*, allowing the feed screw to bear on the ends alone, thereby preventing binding or locking. The end thrust of the screw is taken up by the collar *F*, which is held by two fillister head screws. By placing the adjustable gib *G* on the under side, an easy travel is secured for the tool carrier when in operation. The work performed consists mostly of small special castings varying in diameter from one to seven inches. In this manner the fixture becomes universal to a great extent, and is rendered particularly valuable on account of the shop lacking a turret lathe designed for chucking rather than for plain screw machine work. W. T. M.



Tool Holder for Chucking in the Screw Machine.

"URGE ORDER" SYSTEM.

The cut herewith shows a card of an "Urge Order" system used by The R. K. Le Blond Machine Tool Co. for getting out rush parts, or pieces that are urgently needed for completing a lot of machines. This is not an integral part of the regular shop system but is supplementary to it, and used only for those pieces which have preference over all other work com-

ing through the shop, and for this purpose it has proved very effective. It is the custom to gather all the machine parts, screws, etc., needed to erect a lot of machines several weeks before they are to be erected upon trucks in the stock room to be delivered into the shop when needed. It frequently occurs that some parts that are wanted are not on hand in the stock room at this time, and the object of the system is to get

URGE ORDER Nov 14 1906

☞ The following Thrust Collars are URGENTLY WANTED and must have IMMEDIATE ATTENTION Fill in blanks and return at once.

Jas B SUP'T.

Sym. Name	Amt. Required	When will you deliver?
18" Collars, Piece No. 5-37	63	Nov. 26

Cause of Delay?

Henry Higgins Foreman.

Sym. Name	Amt. Required	When will you deliver?
18" Collars, Piece No. 5-37	63	Nov. 30

Cause of Delay?

C Johnson Foreman

"Urge" Orders of the R. K. Le Blond Machine Tool Company.

these through at once. On these parts work is usually already commenced in the shops, and they are in some partial state of completion.

The number of parts needed is stated on the urge order with the name or mark of the pieces. The order or card is taken to the foreman in whose department the work is. The foreman fills in the date when he will deliver same to the next department and signs his name. If for some cause he cannot promise a delivery owing to the lack of some tool, jig, etc., that he might be waiting for, he indicates this reason on the card. The card is then returned to the superintendent's office, inspected and filed in a dated card index. This index is the usual kind used for similar purposes and has tab cards numbered from 1 to 31. The cards are received daily, and on the day marked on the card it is checked and taken with the work to the next department, to be again dated and signed by the foreman. This is continued until the work is delivered to the stock room. As will be seen, this forms a record of all promises made by the foreman and keeps a constant check on the work until it is finished. W. G.

JIG FOR PLANING CONNECTING-ROD BRASSES.

Having at different times derived ideas from other jig and tool designers, I hereby submit drawings and description of a jig designed this last summer with the hope that someone may derive an idea from it. The pieces to be milled were connecting rod brasses for Corliss engines from 30 x 36 inches down to 10 x 12 inches; two different sizes of this jig were sufficient for all.

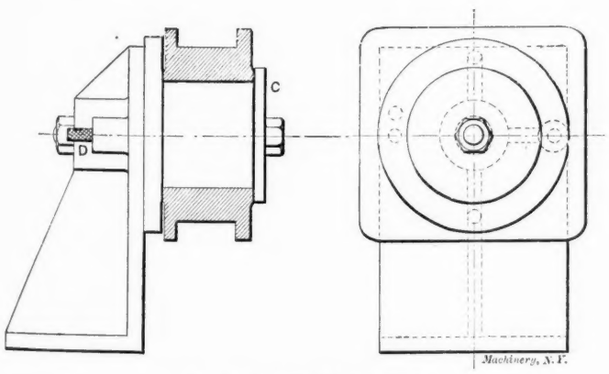


Fig. 1. Jig with Work in Place.

The jig consists mainly of two pieces, as shown in Fig. 2, the angle plate and the revolving faceplate. The jig is so arranged that all four sides, one of which is planed for a wedge, could be milled at one setting by simply turning the faceplate until the index pin engaged in the proper hole. The hole off center is for locating the proper angle when milling the wedged side. The angle plate *A* is made quite stiff, because it has to take the entire cutting strain, without springing to any extent. The faceplate *B* is finished all over. The hole in the center for the studs for holding faceplate and work in position was drilled in the lathe to insure accuracy. It had been our great trouble in the past that we could not with the cheap labor we use, get our work milled square with the bore, which necessitated a lot of filing and chipping. The washer *C*, Fig. 1, is used for locking plate after swinging

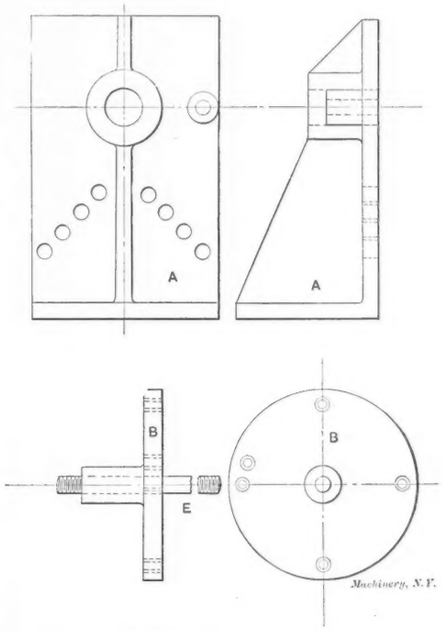


Fig. 2. Details of Jig.

into position and engaging index pin *D*. The holes into which the index pin engages are bushed with taper bushings, made of tool steel and hardened and lapped to fit. The work is centered on bushings the same size as the pin on which the brasses are to run. This enables the operator, by squaring one side, to chuck his work accurately, and all work done is interchangeable. The eight holes drilled diagonal in the angle plate are for the purpose of putting stops to hold the work after it is clamped in position as an additional precaution against slipping. Of course this jig can be improved upon, but at present it is doing the work for which it was designed, doing it better and in one-third of the time of the old way, *i. e.*, using special parallels. R. G. D.

THE STRENGTH OF A MOUTHPIECE RING AND COVER.

In relation to the above article in the November issue (Engineering Edition, page 119) I wish to call attention to a part of a mouthpiece ring which sometimes has proven out to be designed too weak, referring to the danger of failure of the flange at the corner of the gasket groove. I notice, in the article referred to, the words: "The possibility of this would be a rather difficult thing to calculate with assurance, but good judgment would seem to indicate that the casting is none too strong at this point." I think the manner of figuring the strength at this point, which I present, will be of value to those interested in the design of such vessels.

At the left of the cut is shown the ring as suggested. The load ($L + N E$, see the article) is acting with a certain bending moment on the flange of the bolt circle, and trying to break it in the cylindrical area whose height is h and whose length is $2 \pi r$, as shown in the right-hand figure, which is a plane development of the circumference of the ring. Considering the action as being that of a cantilever whose length l is 2 inches, breadth $b = 2 \pi r = 166.5$ inches, and whose depth $= h = 1\frac{1}{2}$ inch. We may obtain the extreme fiber stress as follows:

Bending moment $= (L + N E)\, l$

Resisting moment $= S Z = \dfrac{S b h^2}{6}$

$$(L + N\,E)\,l = \frac{S\,b\,h^2}{6}$$

$$S = \frac{6\,l\,(L + N\,E)}{b\,h^2}$$

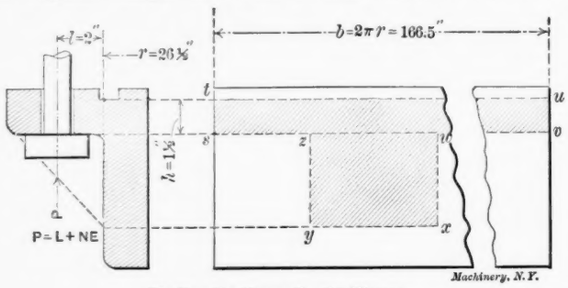
$$S = \frac{12\,(126{,}000 + 24 \times 1{,}200)}{166.5 \times 1.5^2} = 4{,}950 \text{ pounds per square in.}$$

The result of this calculation shows that the factor of safety for the flange is smaller than 5, so that it would be advisable to increase the thickness of the flange to give sufficient strength. An increase of thickness to 2¼ inches gives a unit stress of 3,640 pounds, an amount well within reasonable limits. Instead of increasing the thickness, however, flange ribs, as shown in the dotted lines in the cut, could be provided for getting a higher strength. The development in this case will give two rectangles, the upper one, *s t u v*, being as before, while the lower one, *w x y z*, has a length *y x* equivalent to the total thickness of all the ribs used. Obtaining the moment of resistance of figure *s t u v w x y z*, the unit stress will easily be found.

HERMAN GUMPEL.

Belleview, Pa.

[In calculating the strength of the flange in this manner the stress would be slightly higher even than is indicated by our contributor's figures, since he uses too small a load $(L + N\,E)$, as N should be 36 instead of 24. We made, at the time the article was written, a rough calculation after the manner suggested, carrying it far enough to show that the original design was weak in this respect. We believe,



Finding the Strength of a Flange.

however, that the actual stresses would be somewhat less than would be indicated by a simple solution of this kind. The tendency to bend is resisted, not only by the deformation of the fiber when the section is considered as a beam, but also by the compression of the outer fibers of the flange the moment any bending takes place. We agree with our contributor, however, that the construction is none too strong at the point in question and it could be improved by thickening the flange or by adding ribs. The value of ribbing in a casting of this sort, on general principles, is shown in Prof. Benjamin's article on the bursting strength of cast-iron cylinders in MACHINERY, Engineering Edition, November, 1905.—EDITOR.]

THREADING TOOLS AND THREAD GAGES.

E. A. Johnson.

Of all tool-makers who are employed in the manufacture of taps and dies, there are but few outside of the shops where standard thread plugs and templets are made for the trade who understand how to produce an accurate thread. By an accurate thread I do not mean a precision screw, but a thread which, while a commercial possibility, will measure within a fraction of a thousandth inch of being theoretically correct. It is probably cheaper in a majority of cases to buy gages rather than to make them, but many shops prefer to make their own, especially where the pitch is not standard. In such shops, when a new gage is to be made, the work is usually intrusted to a man who has the reputation of being a "crack-a-jack" at thread cutting, though he may not have the first idea as to what his gage really measures when finished. For such cases the following is intended as a guidance.

The chief requisites for cutting a correct thread are correct threading tools, a correct setting of the tool, and a lathe with a reasonably accurate leadscrew. In making the thread tool a correct 60 degree angle gage is necessary. To produce such a gage first plane up a piece of steel in the shape of an

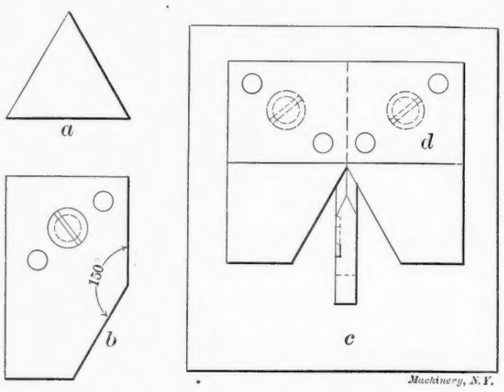


Fig. 1. Gages for making Threading Tools.

equilateral triangle as shown at *a* in Fig. 1. After hardening this triangle, grind and lap the edges until the three corner angles prove to be exactly alike when measured with a protractor. This is now the master gage. To produce the female gage make two pieces, one right hand and one left, like that shown at *b* in Fig. 1; harden them and lap the edges that form the 150 degree angle so that they are straight, and square with both sides. When this is done the two pieces should be screwed, and doweled to a backing plate *d* as shown in Fig. 1, using the master triangle to locate them, thus producing a practically perfect female gage.

In making up the tool some form of cutter to be used in a holder should be chosen in preference to a forged tool on account of convenience in handling and measuring and the feasibility with which it may be re-ground without destroying

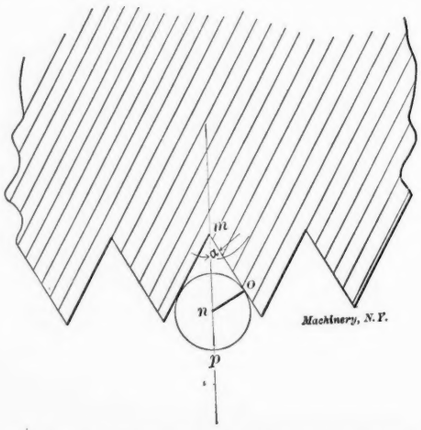


Fig. 2. Measuring the Angle Diameter of a Thread.

the shape. The tool should be made so that the top will stand level when in the holder and the clearance should be about 15 degrees, which is ample for a single thread unless the pitch is very coarse. With that amount of clearance the included angle between the sides of the tool in a plane perpendicular to the front edge is approximately 61° 44′. The tool should be planed to that angle as nearly as is possible by measuring with a protractor, then, to test its accuracy, it should be placed top down on a flat piece of glass *c* and tried with the 60 degree gage as shown in Fig. 1. After lapping the tool until it shuts out the light when tried in this manner, the angle may be considered as nearly correct as is possible to obtain with ordinary means. To adapt the V-thread tool thus made to cut the United States standard form of thread, it is only necessary to grind off the sharp edge an

EUGENE A. JOHNSON was born in Michigan, 1872. He served his apprenticeship with A. F. Bartlett & Co., Saginaw, Mich., and afterward worked for the P. M. R. R., Mitts & Merrill, Veeder Mfg. Co., A. B. Dick & Co., Illinois Sewing Machine Co. and others. At present he is assistant foreman in the screw machine equipment department of the Pratt & Whitney Co.

amount equal to one-eighth of the depth of a V-thread of the required pitch, or for 20 threads per inch $\frac{0.866}{20} \times \frac{1}{8} = 0.0054$ inch. To test the accuracy of this grinding a piece of steel should be turned up to the correct outside diameter and a short shoulder turned down at the end to the correct diameter of the bottom of the thread; then the piece is threaded and the tool fed in until the flat of the tool just tangents the shoulder. Then cut a nick in the edge of a piece of sheet steel with the threading tool. This sheet steel piece is now applied like a gage to the threaded cylindrical piece. If the nick in the sheet steel fits the thread so that it shuts out the light the flat of the tool is correct.

In preparing a plug gage for threading it should be made the same as the cylindrical test piece above with a part turned down to the root diameter of the thread except that for V-thread it is customary to leave the shoulder 0.005 inch large on account of the impossibility of producing a perfectly sharp point on the tool. The thread tool should be set level, with the top at the same height as the center line of the spindle of the lathe, otherwise the correct angle will not be reproduced. After a master plug has once been produced, it is not necessary to turn down a portion to the root diameter of the thread as the work can be compared with the master plug by means of a micrometer fitted with either ball or V points for measuring in the angle of the thread.

It occasionally happens that a tap is to be threaded, or other external threading is to be done, of an odd size or pitch where it is desired to originate a master plug. In such cases the writer uses three wires for measuring the angle of the thread, placing one wire in the angle of the thread on one side of the piece and the other two on the opposite side, one on each side of the corresponding thread, measuring over the whole with a micrometer. The formula for the micrometer reading is obtained as follows: In Fig. 2 assume that m is the bottom of a V-thread, the circle showing one wire in place. Then angle $a = 30$ degrees; sin 30 deg. $= 0.5$; $\frac{no}{0.5} =$ mn or $2no = mn$. As no and np are radii of the same circle, it follows that $mp = 3no = 1\frac{1}{2} \times$ diameter of wire. Multiplying by two to add a length mp for the opposite side gives $2mp = 3 \times$ diameter of wire. Hence for V-thread,

$$\text{Dia. of screw} = \frac{1.732}{\text{No. thds. per in.}} + (3 \times \text{dia. of wire used})$$

= micrometer reading.

For U. S. form we have to take into account the flat at the bottom of the thread, so instead of using the U. S. constant 1.299 we add to it ⅛ of 1.732 or 0.2165 giving as a constant 1.5155, making the formula:

$$\text{Dia. of screw} = \frac{1.5155}{\text{No. thds. per in.}} + (3 \times \text{dia. of wire used})$$

= micrometer reading.

E. A. JOHNSON.

Hartford, Conn.

[The subject of measuring threads with the wire system was treated at length in MACHINERY, January, 1904, in an article by Joseph M. Stabel entitled "Measuring External Thread Diameters."—EDITOR.]

DRAWING TABLE FOR A TECHNICAL SCHOOL DRAFTING ROOM.

F. H. Sibley.

Following is a description of a drafting table that is giving first-rate satisfaction for college drawing room work. Its advantages are strength, compactness and the utilization of what would otherwise be wasted space beneath the tables. The table was designed for the drafting room of the mechanical department at the Case School of Applied Science, and has been in use for about two years. Conditions here made it necessary to construct a cabinet table containing drawers for instruments and lockers for boards and T squares. As several squads of men have to be accommodated at different periods, at the same set of tables, these tables had to be designed so as to discourage the tendency on the part of some students to "swipe" their neighbors' instruments and drawings, and at the same time allow a number of men to use the same desk.

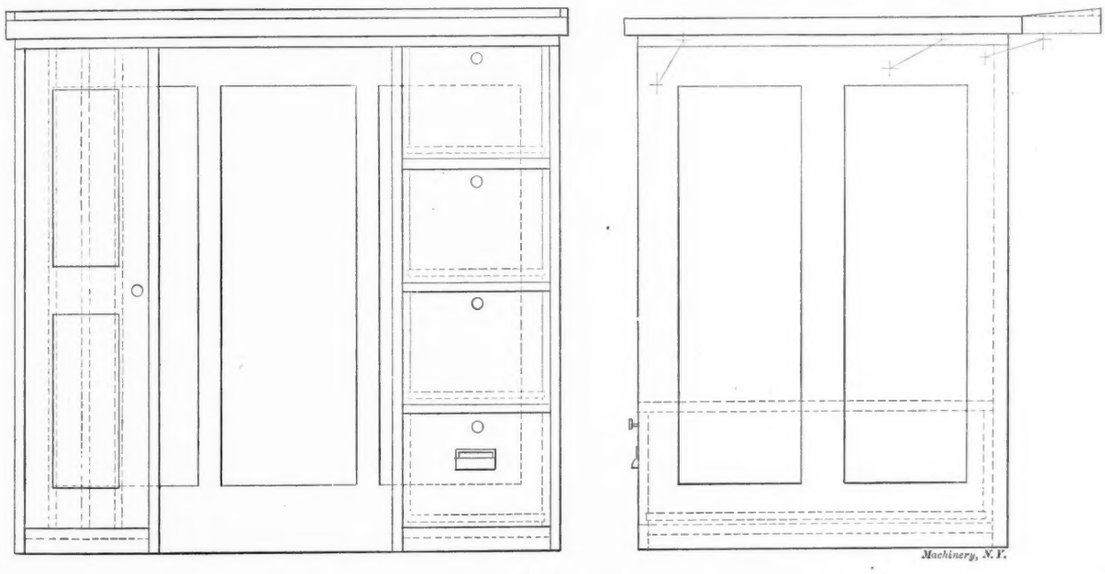


Fig. 1. Front and Side Elevation of Student's Drawing Cabinet Table.

The halftone, Fig. 2, shows the cabinet which has four instrument drawers on the right-hand, and a cupboard on the left-hand side, the latter containing four spaces for boards and T squares. The drawers and cupboard are fitted with combination locks, so that each student has access to one instrument drawer and four boards. Two views of the table are shown in Fig. 1. Its dimensions are 3 feet 5 inches long by 2 feet 3 inches wide and 3 feet 3 inches high to the top of the board when in the horizontal position. The material in the cabinet part is ⅞ inch oak lumber stained a dark color and varnished. The panels in the back and at the ends are ½ inch oak.

F. H. SIBLEY was born in North Oxford, Mass., 1872. He was educated in Brown University and Case School of Applied Science. He served a shop apprenticeship in Worcester, Mass., and has worked for the city of Providence, Geo. Lawley & Son Corporation, Westinghouse Switch & Signal Co., West Shore & Michigan Southern R. R. in the capacity of assistant engineer, draftsman, calculator, etc. He is at present instructor in machine design in the Case School of Applied Science, Cleveland, Ohio.

The instrument drawers are 7 inches deep, 10 inches wide and 2 feet 1 inch long. They are made of soft wood ½ inch thick, except the front, which is of ⅞ inch oak. Besides the lock already mentioned each drawer has a pull with a slot in it for the occupant's name. A stop is fastened to the bottom so that the drawer cannot be entirely removed from its place. This prevents any one from getting at the instruments in the drawer underneath. The board locker is 10 inches wide and extends nearly the whole height of the table. The four board spaces are each 2 inches wide, separated by ½-inch vertical slats. The door is of ⅞-inch oak with ½-inch panels and is hinged on the left-hand side so that it swings clear of the worker's knees. The space between the locker and the tier of drawers is 17 inches wide, allowing ample

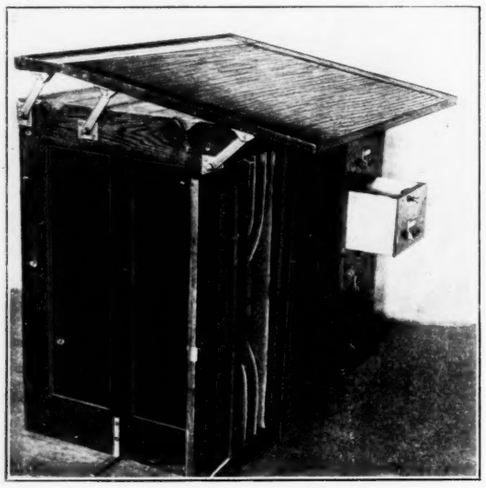


Fig. 2. Drawing Table used in Case School of Applied Science, Cleveland, Ohio.

room to work sitting at the table. A foot rest made of 1-inch gas pipe is to be placed across this space about 6 inches above the floor.

The cabinet is fastened to the floor with two malleable iron brackets and screws. Its top is of soft wood ⅞ inch thick and above it is an adjustable drawing board mounted on iron links. This board is made of butternut wood 1 inch thick. Its dimensions are 3 feet 8 inches by 2 feet 6 inches, and it has strips 3 inches wide jointed to each end to prevent warping. Fastened to the back of the board with 4-inch strap hinges is a leaf with a flange around it for holding instruments and ink bottles. The leaf is attached to the cabinet by links in such a way that when the board is thrown forward to the inclined position the leaf is lifted, but remains horizontal.

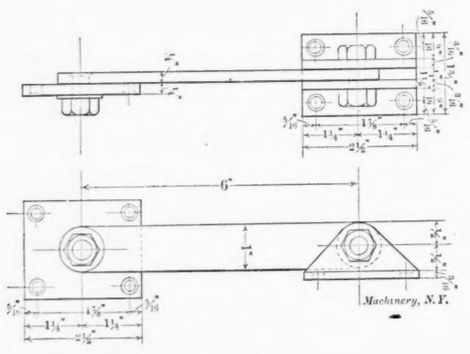


Fig. 3. Details of Link Arrangement.

A detail of the link and its fastenings is shown by Fig. 3 and the arrangement of the links on the board and cabinet in the two extreme positions is illustrated by Fig. 4. The lower end of the link is fastened to a malleable iron plate with a ½-inch bolt, the plate being counter sunk on the side next to the cabinet and the bolts riveted down flush. The plate is then screwed to the cabinet. The upper end of the link is fastened in a small brass or malleable iron bracket with a ½-inch bolt having a nut and washer on each end; in place of the bolt a ½-inch pin having a split cotter at each end has been used. The bracket is screwed to the under surface of the table.

The links are all made the same length, but it is evident that by varying their length and position, the adjustment of the board can be varied to suit the user. In the table here

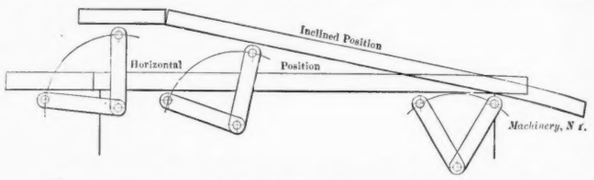


Fig. 4. Diagram showing Extreme Positions of Links and Board.

described the board is thrown forward 7 inches and raised 3 inches at the back, giving it a slope of about 12 degrees. For maximum strength and stiffness the links under the leaf at the back ought to be in nearly a vertical position when the board is thrown forward. The board should also, when in this position, have a solid bearing on the front edge of the cabinet for if supported by the links alone it will not be steady.

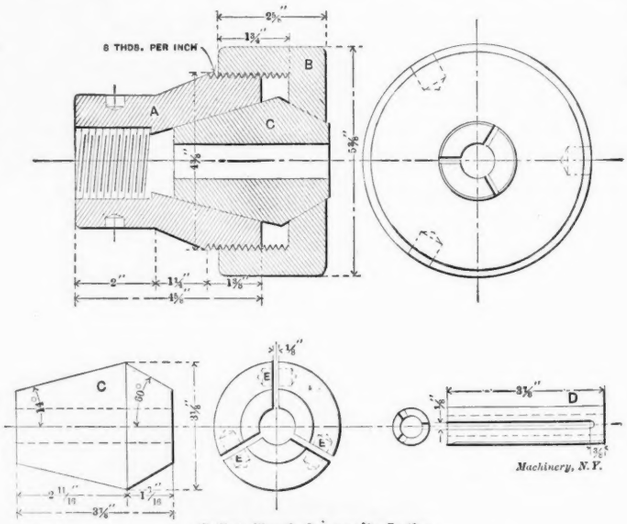
These tables were built by contract for $14.50 each, exclusive of the iron work. The cost of locks and fittings, links, hinges, etc., with labor for putting on same amounted to about $4.00 each, making the total cost of each table about $18.50.

In operation, four men, working at different periods, are assigned to a table, a book list of the lock combinations is kept, with the user's name opposite the combination. The scheme makes it possible to accommodate a varying number of students, without filling up the drafting room with lockers which are in use only a small part of the time. By locking together the drawing boards in groups of four, space is greatly economized at the same time as drawings may be left on them over night without much danger of loss.

Cleveland, O. F. H. SIBLEY.

COLLET CHUCK.

The chuck shown in the accompanying cut consists of three parts, the sleeve *A*, the knurled nut *B*, and the split collet *C*. The sleeve *A* is threaded to fit the spindle of the lathe and



Collet Chuck for use in Lathe.

bored to receive one end of collet *C*. The nut *B* is bored to receive the opposite end of the collet *C* and has three holes drilled in the outside for the spanner wrench. The tightening of this nut forces *C* against the taper in *A*, thus gripping the work. Several collets of different bores should be made for different sizes of stock. Sizes under ⅞ inch can be conveniently held by making steel sleeves as shown at *D* in the cut. The collet *C* is split in three parts and drilled, as shown at *E* in the detail of the collet, for coiled springs, which force the jaws apart when the nut *B* is loosened, thus allowing the work to be removed easily. H. H. WILKINSON.

Salem, Ohio.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.
Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

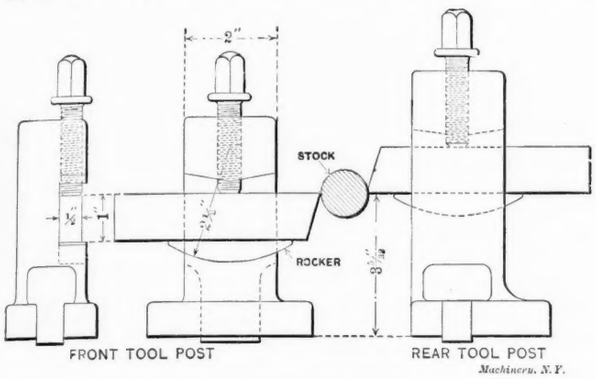
CLEANING TOOLS WITH AN INK ERASER.

A very convenient way of removing rust and brightening surfaces of tools, such as steel scales or brass and German silver protractors, is to rub the surface with a common ink eraser. It does not scratch the surface as emery cloth does; it is always at hand for a draftsman and would also be appreciated by a machinist. WM. H. KELLOGG.

Chicago, Ill.

IMPROVED TOOLPOST FOR THE SCREW MACHINE.

The toolposts on the Garvin screw machine cross slide were giving me a great deal of trouble both in regard to failing to hold the tool rigidly, and on account of the breaking off of

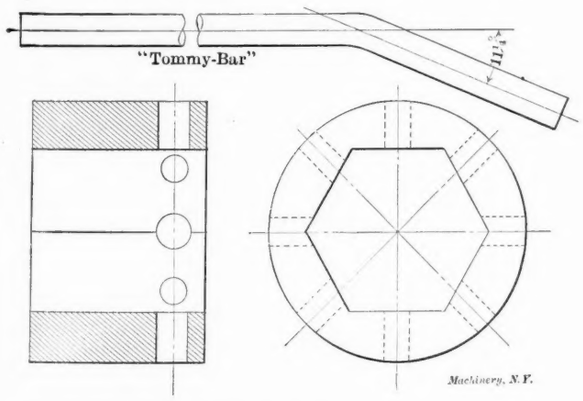


the part which fits in the T-slot, due to the pressure sidewise. I therefore decided to design a toolpost which would stand up under all conditions with the result shown in the accompanying cut. C. W. PUTNAM.

New York City.

SIMPLE SOCKET WRENCH.

I had occasion to tighten a ¾-inch nut in a position where an ordinary wrench could not be used. The socket shown in the cut was made, having a hexagon hole for the nut. Through the top of the socket eight holes were drilled 45 degrees apart for a steel rod which was used as a handle or "tommy-bar." This pin, being bent at an angle of 11¼ degrees, enabled the



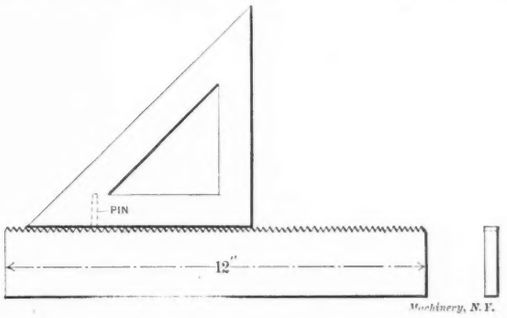
nut to be turned one-sixteenth of a turn for each position of the pin, and thus permitted the nut to be tightened with a very short angular movement of the handle.

Auburn, N. Y. JOSEPH ROACH.

[This scheme is a good one for the purpose described. We recently saw it in use in the Schenectady plant of the General Electric Co. on 3-inch nuts, these being located in a generator frame where an ordinary wrench could not be employed. The simplicity of construction, ease of operation and effectiveness will commend this form of wrench to all who have use for such a tool.—EDITOR.]

SECTION LINER.

The accompanying cut shows the principle of a section liner which, although simple, answers the purpose fully as well as some of the more complicated and expensive arrangements. It consists of a piece of brass or any metal 12 inches long with threads cut on one side as shown, about 40 threads



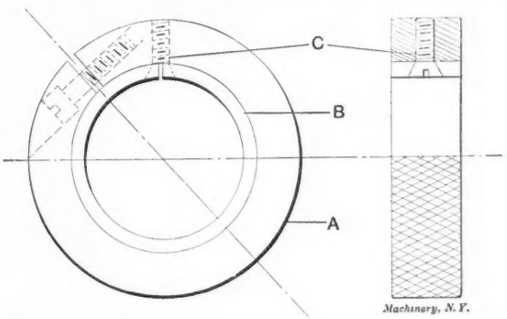
to the inch, a wooden triangle and a pin driven in as indicated and filed to fit the thread into which it is to engage. The other boys and myself have used it and find it to be a good thing. JOHN H. CRAIGIE.

Boston, Mass.

ADJUSTABLE RING GAGES.

There are plenty of precise mechanics who will say that adjustable tools and gages are unsafe, and that because of this particular feature some workmen are apt to get an adjustment over or under size and spoil something. While this really is true in a measure, the same workman could, with a new sharp tap or reamer, make a hole too large, or too small with one that was worn and dull. Adjustable tools are a great help and if properly used will never cause trouble.

The cut shows one of the most satisfactory adjustable ring gages I know of, having used this form quite a number of years and prefer it to others. It is adapted for either thread



or plain gages, being used in both forms. *A* is a soft split steel ring. *B* is a split tool steel ring, hardened, ground, and lapped. The cylindrical truth of the gage remains perfect at different adjustments. The adjusting is done by the screw *C*, which should have a wood screwhead, 30 degrees included angle. This gage is both a convenience and a time saver—a practically solid gage in a few minutes changed from a standard size to several thousanths inch plus or minus. After the gage is adjusted to the desired size, which is easily and quickly done, it is as substantial as a solid gage. M. S. W.

PERMANENT SET OF SPIRAL SPRINGS.

The question and answer regarding spiral springs in the November issue of MACHINERY interest me. Evidently "F. S." met difficulty in attempting to prevent the spring from taking a permanent set. I should suggest that the spring be manufactured with an increased pitch, so that after hardening and tempering the permanent set may be taken out by compressing solid. If the spring still remains too long, a little more tempering will bring the desired result. It will be impossible by any method of hardening or tempering to prevent a spring of the dimensions given from taking a permanent set. Furthermore, do not consider that closing the coils tightly together will take out the entire set, but the spring must be compressed solid for ten or fifteen hours before the permanent set can be entirely overcome. A.

SHOP RECEIPTS AND FORMULAS.

A DEPARTMENT FOR USEFUL MIXTURES.

This page will be used for the publication of shop receipts which the contributors know from experience to be practicable. Nearly all readers of MACHINERY can add something, and it is desired that they use this page as a medium for exchanging useful formulas. It makes no difference if they are old and supposedly well-known, provided they have not already appeared in this department.

283. MALLEABLE BRASS.

Brass which possesses malleability in a high degree can be obtained by alloying 57 parts of copper with 43 of zinc.

Pittsburg, Pa. U. PETERS.

284. STEAM PIPE CEMENT.

Mix equal parts, by weight, of oxide of manganese, pipe clay and white lead, ground with linseed oil varnish.

West Somerville, Mass. E. H. MCCLINTOCK.

285. TO TURN VERY HARD IRON AND STEEL.

Use a drip can for the tool with the following solution: petroleum, 2 gallons; turpentine, 1 gallon, and 2 ounces of camphor. J. H. HOLDSWORTH.

Toronto, Canada.

286. TO BLACKEN ARTICLES WHICH ARE NOT SOLDERED

Heat the article to a low heat and dip into a solution of nitrate of copper, made by dissolving copper in nitric acid. Then heat the piece dipped over a spirit lamp or Bunsen burner until from greenish color it finally turns black.

Bridgeport, Conn. H. A. SHERWOOD.

287. ALLOY FOR FILLING HOLES IN CAST IRON.

Melt together 9 parts of lead, 2 parts of antimony, and 1 part of bismuth, and pour this mixture into the hole, first somewhat warming the hole. This alloy possesses the quality of expanding when cooling, hence becomes solid in the holes when cold. E. J. BUCHET.

Dubuque, Iowa.

288. MIXTURE FOR HARDENING SPIRAL SPRINGS.

The following oil bath mixture gives excellent results for hardening spiral springs: Two gallons best whale oil, 2 pounds Russian tallow, and ½ pound rosin. Boil the tallow and the rosin together until dissolved; add the whale oil and stir up well, and then it is ready for use.

Birmingham, Eng. W. R. BOWERS.

289. TO CASEHARDEN CAST IRON.

To caseharden cast iron use a pot of suitable size for the piece, packing it in with 2/3 raw bone and 1/3 charcoal ground to about the same size as the bone. Seal the pot cover with fire-clay and place in a furnace and run it about 5 hours. Then take out the work and dip in oil or water.

E. W. NORTON.

290. TO TURN ALUMINUM.

To produce a smooth surface when turning aluminum use kerosene oil for a lubricant. If turning in a turret lathe provided with an oil pump, mix the kerosene oil with lard oil, 1 part of lard oil to 3 parts of kerosene, as kerosene itself is too thin to be fed through the ordinary oil pump without being mixed with a more heavy flowing fluid. Kerosene oil is also the best lubricant for use in boring, threading and reaming aluminum. JOHN C. MONRAD.

East Hartford, Conn.

291. TO CLEAN TRACINGS.

Tracings that have become badly soiled from handling or other causes, may be easily cleaned by thoroughly sponging the cloth with benzine or gasoline. Kerosene will serve the purpose, but is not so good. It does not injure the cloth in the least, but on the other hand has the effect of re-establishing the color of a much used tracing, and will remove pencil marks perfectly. When some compound has been used on the tracing to remove the ink lines, leaving a sticky and gummy surface, benzine will quickly clean and dry the affected portion, so that it can be worked over again.

Olney, Ill. T. E. O'DONNELL.

292. TO COAT IRON WITH COPPER.

Polish the iron by rubbing it well with cream of tartar, and afterward with charcoal powder, and place the metal in hydrochloric acid diluted with three times its volume of water, in which a few drops of a solution of sulphate of copper is poured. After a few minutes withdraw the iron and rub with a piece of cloth, then replace it in the solution, to which add another portion of sulphate of copper. By following on this plan the layer of copper may be increased at pleasure. Finally, immerse the iron in a solution of soda, wipe clean and polish with chalk. The coating thus obtained will be as firm and durable as that deposited by the electrotype process.

Pittsburg, Pa. U. PETERS.

293. STEEL BLUE ENAMEL.

A steel-blue enamel suitable for applying to steel and also other metals to give them a steel-blue polished surface, may be made in the following way: Dissolve 1 part of borax in 4 parts of water. Macerate 5 parts bleached shellac in 5 parts of alcohol. In a small quantity of alcohol dissolve some methylene blue of sufficient amount to give the color desired. Heat the first or watery solution to boiling, and while constantly stirring add the alcoholic solution. Stir until all the lumps are dissolved, and then add the blue solution. Before applying, the surface to be blued should be cleaned and brightened with emery cloth. The enamel is best applied with a soft brush. The solution may be put into a bottle and set aside for future use, provided the bottle is securely corked.

Olney, Ill. T. E. O'DONNELL.

294. TO PREVENT DRAWING TITLES FROM SMEARING OR RUBBING OFF.

A great many of our railroads and large manufacturing concerns throughout the country are using small printing presses for the purpose of putting titles on their drawings. It is titles put on in this manner with tracing cloth printing ink to which I refer. After the title has been printed on the drawing, lacquer it over with a very thin coat of French varnish (such as is used by artists). This can be best applied with a chisel-shaped camel's hair brush, equal in width to the height of the letters in the title. A good substitute where French varnish cannot be obtained is made by cutting ¼ ounce of the best grade of white shellac in ½ pint of alcohol. As either of these varnishes dry very quickly, the tracings may be used soon after the titles are put on.

Meadville, Pa. E. W. BOWEN.

295. SATIN FINISH ON ALUMINUM.

The article should first be dipped in a caustic soda or caustic potash solution—potash preferred—then thoroughly washed in clear water and dipped in a bath of concentrated nitric acid, after which it should be thoroughly washed and dried in hot sawdust. The caustic solution should be prepared in a tank provided with a steam coil and should test with Baumes' hydrometer at anywhere between 20 and 30. The length of time an article should remain in the caustic solution is a matter of judgment. The solution should attack the aluminum rapidly, and upon removing the article from the solution, the solution should boil furiously on the metal. After washing, the article should show a very black color, which turns to a silvery white finish upon dipping in the nitric acid. The best temperature for the caustic solution is at 200 degrees F., just below the boiling point. By the use of a steam coil the solution can be kept at an even temperature, and the strength of the solution can be maintained by adding small quantities of caustic from time to time. The temperature and strength of the solution are very important.

The principal point to bear in mind in washing and drying is to dry without streaks, which is accomplished if the sawdust contains no pitch or rosin.

This finish can be improved by scratch-brushing the article before dipping or by first dipping in the two solutions and then scratch-brushing and afterward dipping again. The scratch-brushing destroys the grain of the metal and reduces the possibility of the article drying with streaks.

Bridgeport, Conn. S. H. SWEET.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

36. A. L.—Please give a general rule for finding the angular setting of a milling machine head when it is required to mill a flat side on a tapered pin which shall be proportional in width throughout its length to the varying diameter of the pin. For example, what is the proper setting for the milling machine head when making four-sided reamers for standard taper pins ¼-inch taper per foot?

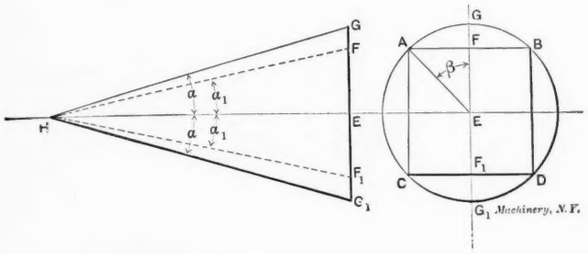
A.—Divide one-half the taper per foot by 12, and multiply the quotient by the cosine of 360 divided by two times the number of sides. The result is the tangent of the required setting of the index head. Expressed as a formula, using the symbols and lines shown in the cut we have

$$\tan a_1 = \frac{G\,E \times \cos \beta}{H\,E} = \frac{\frac{1}{2}\,T}{12} \times \cos \frac{360^\circ}{2\,N}$$

a = one-half included angle of cone.

a_1 = angle made by flat with the axis or center line.

$$\beta = \frac{360^\circ}{2\,N}.$$



N = number of sides.

T = taper per foot.

Expressed in words, the formula reads:

$$\text{Tangent angular setting} = \frac{\frac{1}{2} \text{ taper per foot}}{12} \times \text{cosine} \frac{360 \text{ degrees}}{2 \times \text{number of sides}}.$$

Taking the quoted example, we have:

$$\text{Tan } a_1 = \frac{\frac{1}{8}}{12} \times \cos 45 \text{ degrees.}$$

$$= \frac{\frac{1}{8} \times 0.707}{12} = 0.01041, \text{ the tangent of the required angle.}$$

Referring to a table of tangents discloses that the angle is 25 minutes, or the required setting.

35. A. L. F.—Having given the number of teeth and the pitch angle (or edge angle) of a bevel gear, how can I find the number of teeth of the mating gear, the axes being at 90 degrees?

A.—The number of teeth in the given gear is to the sine of its pitch or edge angle as the number of teeth in the mating gear is to the cosine of the pitch angle. For example, suppose the pitch angle is 56 degrees 59 minutes and the number of teeth is 40. The sine of 56 degrees 59 minutes is 0.83851, and the cosine is 0.54488. Hence $40 : 0.83851 = x : 0.54488$, or $x = 26$, the number of teeth in the mating gear. You will observe that the result figures almost exactly 26 teeth; if it does not closely approximate a whole number then the pitch or edge angle is incorrectly given for, of course, no fractional tooth numbers can be used. The rule may be used to give both of the two possible combinations of a pair of bevel gears. Let us take for example the case of a pinion having 40 teeth, assigning to it for the moment the pitch angle 56 degrees 59 minutes, then the nearest whole number of teeth in the mating gear is 62, but the actual result is 61 and a fraction. Taking 62 as the probable number and working backward we find that the actual pitch angle of the 62-tooth gear must be 57 degrees 10 minutes. The method of finding this is simple: square the numbers of teeth in each gear, add their squares, extract the square root and divide either number of teeth by the root. The quotient is the sine of its pitch angle. To illustrate: $\sqrt{62^2 + 40^2} = 73.78$; $62 \div 73.78 = 0.84034$, the sine of 57 degrees 10 minutes. If, instead, we divide 40 by 73.78 the quotient is the sine of the pitch angle of the 40-tooth pinion, or 0.54216, the sine of 32 degrees 50 minutes. Of course it is simpler to subtract 57 degrees 10 minutes from 90 degrees, but the foregoing illustrates the process more clearly.

* * *

A GROUP OF LARGE REAMERS.

The constant extension in the range of usefulness of the adjustable reamer could not be shown in a much better way than it is in the group pictured below. Probably the dimensions of these tools will seem rather large to most mechanics, and indeed it is rather difficult to imagine just what field of usefulness has been found for adjustable reamers of this size.

Group of Large Reamers.

They were built to order, however, by the makers, Schellenbach & Darling Tool Co., Cincinnati, Ohio, and the purchaser doubtless has confidence in their capabilities. The diameters of these tools are as follows: 7¾, 8, 9¾, 10, 11¾, 12. The bores are 4 inches, 4½ inches and 5 inches respectively. The smallest shell reamer shown (at the top) is 1½ inch in diameter, the hand reamer at the bottom is 11/16 inch in diameter. The whole group weighs in the neighborhood of 1,000 pounds and certainly represents a remarkable feat in toolmaking.

* * *

One of the drawbacks to the use of wire hoisting rope has been the spinning to which it is ordinarily subject when raising a load. This is troublesome and dangerous, as oftentimes a bucket will spin so rapidly that the material loaded above the rim will be thrown off by centrifugal force and cause the injury of workmen beneath. We understand that a rope is now on the market which is not subject to this trouble, it having little or no tendency to spin as the load is raised or lowered. This example shows one the peculiar difficulties that mechanical engineers are often required to overcome. New questions in engineering are arising every day for which there is little or no direct precedent, but the solutions may often be found by analogy, reasoning from the known action of materials under similar conditions, but used for entirely different purposes.

* * *

One of the oldest blast furnace blowers in the world is undoubtedly one still in existence at the Lowmoor Iron Works in England, which according to the *Foundry Trade Journal* was built in 1791. The blast furnace itself, which was built in 1802 is also still preserved.

MACHINERY AND TOOLS.

A MONTHLY RECORD OF NEW APPLIANCES FOR THE SHOP.

PRECISION GEAR-CUTTING MACHINERY.

The Sloan & Chace Mfg. Co., Newark, N. J., concerning whose work we have had something to say in this and the preceding issue of MACHINERY, have recently built an automatic gear cutter and an automatic rack cutter of larger size than their regular line of machinery, to meet the demand for the larger gears used in light mechanisms and instruments of various kinds. This work includes that required for cash registers, typesetting machinery, the heavier parts of typewriters, etc.; but the gear cutter shown has given such a good account of itself on comparatively heavy work that gears as large as those used in automobile construction are found to be easily within its range.

In the rack cutter shown in Fig. 1, the general design is that of the milling machine. The rack cutting spindle is driven from the main spindle by suitable gearing enclosed within a case, the axis of the cutter spindle being parallel, naturally, to the direction of the index travel of the work table. The movements of the machine, other than the rotating of the cutter, are accomplished by a vertical cam-carrying shaft, driven by the bevel gears and worm wheel shown attached to the knee. This gearing takes its motion

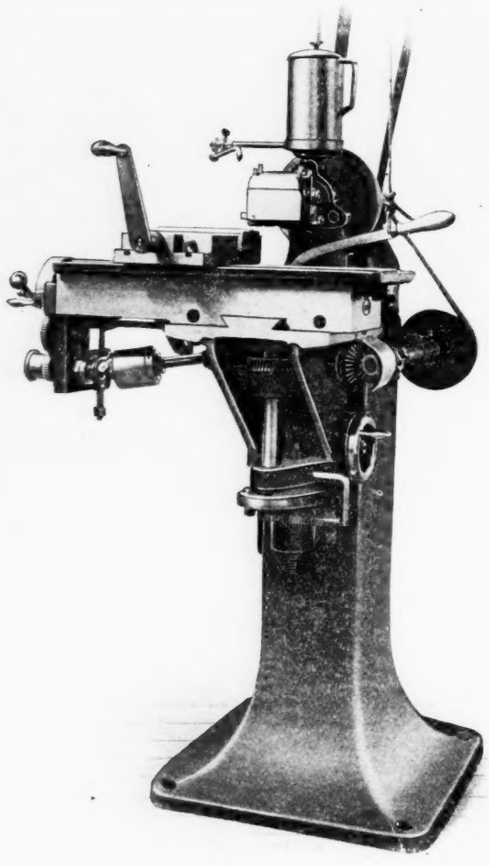


Fig. 1. Sloan & Chace Automatic Rack Cutter.

from a belt connected to the spindle at the back of the machine. The cam shaft referred to is the heavy vertical shaft journaled in bearings in the knee beneath the table; this shaft makes one revolution for each tooth cut, if a single cutter is used, or for each feeding stroke of the table if a multiple cutter is used. The cam for feeding the saddle inward for the cutting motion and backward for the return, is located at the upper end of the shaft. At the lower end is another cam, not clearly shown, which allows the knee and table to drop on the return stroke, thus relieving the cutter. This is effected by the partial rotation of a screw having a very coarse pitch, threaded into the boss projecting from the front of the column. Within this screw, but prevented from rotating with it, is a nut on which the elevating screw of the knee acts. Immediately on the completion of a cut, the partial rotation of the first mentioned coarse pitch screw, under the influence of the cam, thus serves to depress the elevating screw and with it the knee and the work, raising it again to its former position

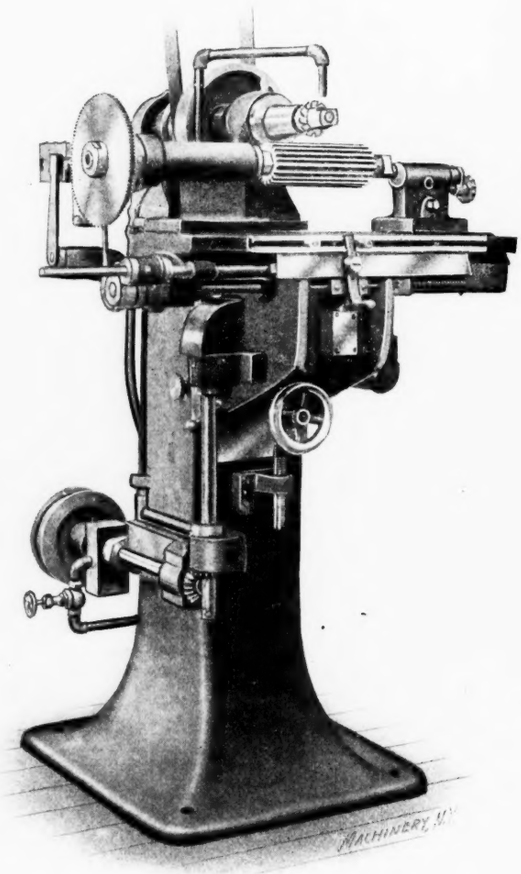


Fig. 2. Sloan & Chace Automatic Gear Cutter.

as the upper cam again commences to feed the work forward toward the cutter. A continuation of the bevel gear-driven shaft, which through the worm gearing rotates this cam shaft, operates the indexing mechanism, motion being conveyed to the change gearing at the right-hand end by a telescopic shaft with universal joints and a friction slip device. A trip on the vertical cam shaft releases the index gearing at the proper time when it is rotated through a complete revolution by the friction drive. An adjustable stop at the back of the work table, not shown in the cut, releases the shipper lever whose handle is seen projecting at the right, and stops the machine after any desired number of teeth. The countershaft used has a spring return and is held in engagement by the locking of this lever at its lowest position. The whole mechanism is thus arrested as soon as the last two have been cut with the work dropped away from the cutter and brought outward to the full extent of the return stroke.

The gear cutter shown in Fig. 2 shows plain evidences of the watch machine makers' ideas in its design, but it is intended to show the watch machine makers' ideas in the accuracy of its workmanship as well. The column is practically the same as that of the machine just shown. It is of the same general milling machine design. The cutter, of which a comparatively coarse pitch is shown in the cut, is mounted on an arbor in a rugged prolongation of the main spindle. The work is held between centers and is indexed by a notched

disk, as is usual in precision machine practice. The various movements, other than the cutting feed, are obtained from the pulley shown near the base of the column at the left-hand side. From here the motion is transmitted to the knee by means plainly visible. A feed screw is used in this case instead of a cam employed in the rack cutter shown in Fig. 1. The quick return of the feed motion is effected by the connections just described, while the forward feed is driven by a three-speed change gear box on the other side of the machine. The three feeds obtainable are approximately 0.010, 0.017 and 0.030 per revolution of the spindle. With the four-pitch cutter shown in place in the machine, without the slightest signs of distress in machine, cutter or work, 6½ inches per minute have been obtained in cast iron, 2⅛ inches per minute in machine steel, and 7¾ inches per minute in bronze. The travel of the table is determined by stops fastened in a T-slct at the front acting on a clutch lever which throws in, in turn, the feed and the quick return. A rather ingenious indexing mechanism, which entirely avoids the use of spring action in the withdrawal of the locking pin and the indexing of the work, rotates the blank the proper amount on the first half turn of the feed screw at the commencement of the feeding movement. A one-revolution clutch has been provided for this motion which has been specially designed to be operative even when the parts are rotated by hand at a very much slower rate than would occur when the machine is power driven. All the gears in the knee and the change gear box are of steel.

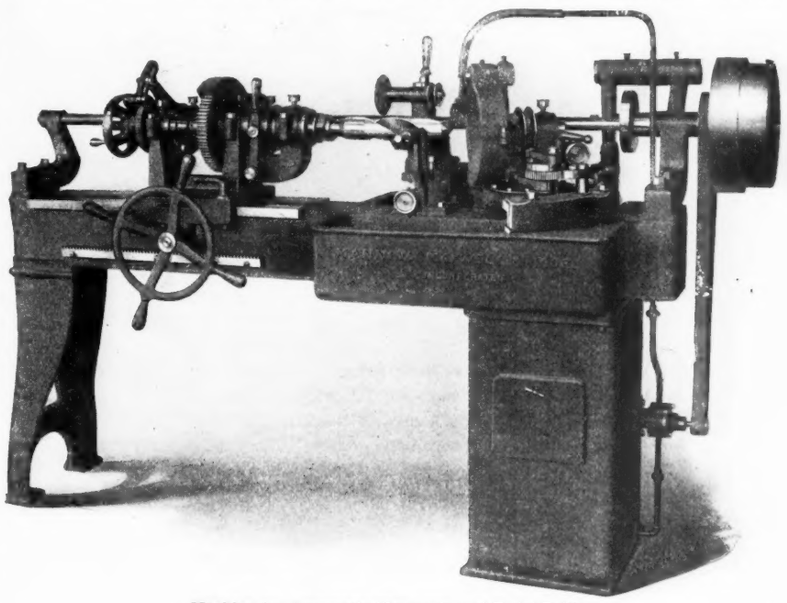
The head is adjustable in and out of the bed for centering the cutter. It has a three-step cone for a 2-inch belt, and gives speeds of 121, 217 and 312 revolutions per minute to the cutter. In both the spindle and the work arbor the usual No. 10 Brown & Sharpe taper is provided. For cutting steel the work table is provided with a pan lip, and an oil pump is arranged to be driven by the quick movement shaft at the lower left-hand side of the column; the reservoir for oil is inside of the frame. The makers call this their No. 3 automatic gear cutter.

THE DAHL AUTOMATIC DRILL GRINDER.

A glance at the accompanying halftone shows that this drill grinder is decidedly different from the type to which we have become accustomed in the last ten or fifteen years. There is, in fact, almost no element in this mechanism corresponding in any particular to that of the usual machine. The drill is placed in the chuck of this machine, brought up to the wheel, and the machine is started, after which it continues to grind the end of the lips to the proper contour until the dull portion has been removed when the operator, who has not meanwhile touched the machine, throws off the power and removes the drill.

A shaft at the rear extending the whole length of the bed and driven by the two-step cone at the right, furnishes the power for all the movements, excepting the rotation of the emery wheel itself. The wheel is of the cup type, grinding on its face, and is mounted on an independent spindle driven by a round belt from the countershaft. On flat ways on the left end of the bed is mounted a carriage provided with a quick traverse movement through the pilot wheel shown. This carriage carries the work-holding spindle, which is provided with a tapered hole and suitable collets for holding the drill in the same way it is held in the drill press. The spur gear shown in this spindle meshes with a pinion of half its diameter on the driving shaft in the rear, so that for every revolution of the spindle, which rotates continuously, the driving shaft makes two revolutions. After the work has been once set, the carriage is clamped in place by the handle shown at the right of the pilot wheel. The feed of the drill toward the wheel, as the grinding progresses, is accomplished by the mechanism shown at the rear of the carriage or an extension of the drill holding spindle. An eccentric on the rear driving shaft, acting on the feed screw, through the levers and ratchet wheel plainly shown, advances the drill a little at a time as each lip passes the face of the wheel. A slotted link in the connection between the eccentric and the ratchet wheel allows a variation in feed to suit the size of the drill and the amount of stock to be removed. As will be seen later, it is necessary that the cutting edge of the drill should preserve a constant angular position in relation to the driving shaft at the rear. To preserve this relation, use is made of the gage pin shown in the V-block support in which the outer end of the drill rests. With the back shaft in a definite position, the clutch is loosened by the operating lever seen between the right hand and the central bearings of the work spindle, and the drill is rotated until its cutting lip is properly located with reference to the gage just mentioned. The clutch is then thrown in again, when the drill and the other mechanism of the machine are fixed in proper relation to each other.

The wheel itself, driven from the countershaft by a round belt as before described, is mounted in a headstock which is free to swing about a vertical axis passing through the center line of the drill and its spindle, near the point of the drill. The cam shown on the back shaft just at the left of the right-hand bearing next to the pulley, through a system of levers,



Machine for Automatic Sharpening of Twist Drills.

imparts to the headstock and the wheel mounted in it a vibratory motion about its vertical axis, performing two complete cycles for each revolution of the drill by virtue of the fact that the driving shaft and work spindle are geared in the ratio of 2 to 1, as before described.

The action of the machine will now be readily apparent. The drill, rotating continuously and fed forward slowly, is pressed against the face of the revolving wheel which, being set at the proper angle for the cutting edge, is swung around to a gradually increasing angle as the heel of the drill is presented, thus giving to the tool its proper clearance. As the second cutting edge approaches, the cam swings the wheel back out of the way until the lip reaches the proper point for presentation to the wheel which, as before, swings in toward it again following the curve around to the heel. The drill, meanwhile, is advanced a slight amount by the feeding mechanism between the grinding of each lip.

A number of interesting points will be noticed in the mechanism. Provision is made, for instance, to insure an even wear across the whole face of the grinding wheel. At the front of the pivoted carriage on which the wheel is mounted will be seen a ratchet wheel adapted to engage with a stationary dog on the bed. As the wheel support is vibrated under the influence of the cam, this ratchet wheel passes toward and away from the dog in turn, receiving by this action a step by step rotating movement. To this ratchet

wheel is attached a crankpin and a connecting rod, which is, in turn, pivoted to a stud in the headstock casting, which carries the wheel. This headstock is not one piece with the pivoted carriage which forms its base, but is fastened to it through sliding ways. The gradual rotating of the ratchet wheel through the medium of the connecting rod gives to the wheel a slow reciprocating movement which continually presents to the work a new portion of the grinding face, over which the wear is thus evenly distributed. Messrs. Manning, Maxwell & Moore, Inc., 85-87-89 Liberty St., New York, who have placed this machine on the market, make the following claims: An unskilled operator can grind a drill at a true angle without difficulty; the adjustments for taking care of drills of different sizes from ½ to 3½ inches in diameter, are rapid and simple; the design of the machine insures equal height and even cutting on the lips of the drill; the wear on the face of the emery wheel is uniform. Suitable gages are provided for adjusting the wheel to make allowance for wear. A separately-driven small wheel is provided for thinning the points of the drill. This operation is performed without removing the drill from the machine. The wheel for this is shown in the position it occupies when not in use, at the rear of the drill being sharpened. The machine weighs approximately 1,900 pounds and is furnished regularly with one large emery wheel, one small wheel, and bushings for tapered shanks. Each machine is furnished complete with countershaft and necessary wrenches.

THE WESTERN ELECTRIC CO. SHORT ARC LAMP.

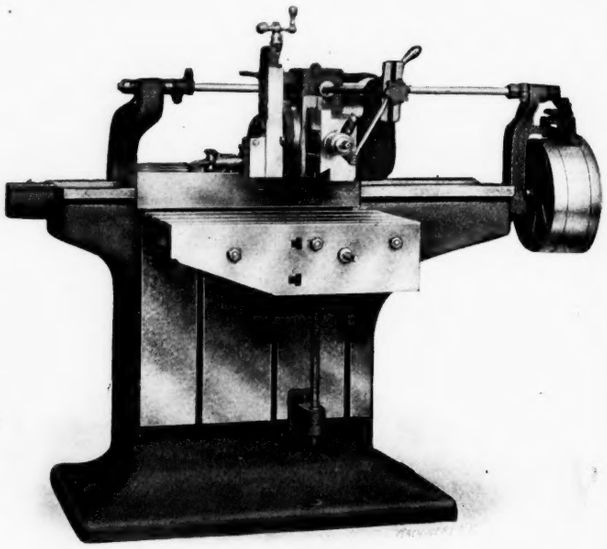
To meet the demand for a line of arc lamps to use in places where head room is scant, the Western Electric Co. of Chicago have designed the lamp shown in the accompanying cut. They believe that they have attained a more graceful and pleasing form, a more compact arrangement, and a better light distribution than have been reached by other manufacturers who have attempted a solution of the same problem. The over-all length has been reduced to the minimum obtainable, it being but 20 inches from the top of the lamp to the lower end of the inclosing globe; and this has been done without reducing the length of the carbon enough to materially cut down its life below that obtained in the ordinary five-ampere lamp. A life of 100 hours with each trimming is guaranteed. Instead of the large bulky case ordinarily found in short lamps, the use of indestructible windings and specially designed resistance units has resulted in very small dimensions and a design quite as symmetrical as that of the standard type manufactured by the company. In the choice of material for the different parts, only such have been used as have been found adapted for rooms where considerable heat is liable to be met with. The lamps are expected to be used in low cellars, engine rooms, boiler rooms, etc., so that this precaution is a necessary one.

An Arc Lamp for low Ceilings.

It is found quite difficult in practice to apply any effective safeguard against injury by the use of fuses in lamps of this kind as ordinarily constructed, and it is not infrequently found that elements, which were thought to have been provided against, have wrought serious damage. In the new lamp provision is made to preserve it from injury even where fuses are omitted. The lamp may, in fact, remain with the arc entirely short circuited for hours without material injury; after which it will be found ready for normal operation the moment proper conditions are restored. This lamp may be obtained for use on 110-volt or 222-volt circuits, direct current.

THE CINCINNATI OPEN SIDE SHAPER OR PLANER.

The shaper of the "Richards" or "open side" type has so many advantages over the usual type for some kinds of work, that it seems strange that it has not come into more common use. Among other good points the design possesses, is the property of not making a "fan tail" cut; that is to say, the aggregate of the deflections of the members of the machine is constant throughout the stroke. It is not constant, of course, between the first stroke and the last stroke, but since most shaper cuts are longer than they are wide, the tendency of this condition is toward greater accuracy. On this machine also there is practically no limit to the diameter of shaft which can be key-seated. In the ordinary shaper usefulness in this direction is limited by the size of the opening through the column under the ram. The Richards shaper can be used on castings which are entirely beyond the range of the ordinary tools, for taking cuts of certain kinds; in fact, it may be said to have the advantages of the open side planer in this respect without its disadvantage of requiring the moving of the work back and forth.



Richards or Open Side Shaper, Built by the Cincinnati Shaper Co.

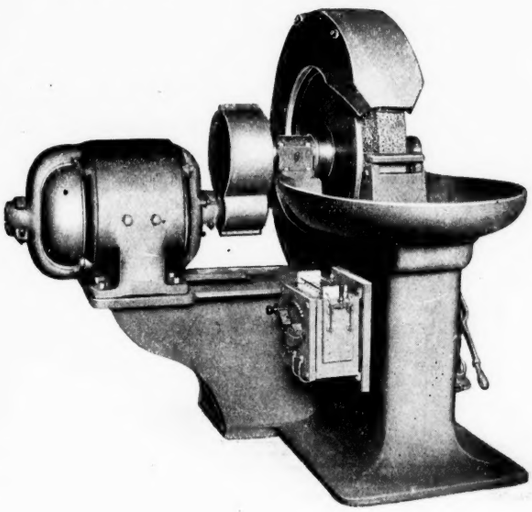
The machine here shown is the smallest of the line recently designed by the builders. It planes an area of 15 inches wide and 30 inches long. The ram is driven by a single screw and bronze nut without the intervention of any gears, this screw being 2⅛ inches in diameter and made of 0.50 carbon steel. The saddle has a long and wide bearing on the column with a narrow and deep guiding surface to prevent binding, particularly when the tool is at the outer end of the rail. A taper gib, adjustable longitudinally by means of screws at each end, is used to take up the wear uniformly throughout the length of the slide. The reversing mechanism, which is of the planer type, is operated by a means original with the builders. The rod extending across the rear of the machine is provided with stops adjustable longitudinally to vary the length and position of the stroke; two projecting wing-like cams at the rear of the slide are adapted to engage these stops; this engagement rotates the stop rod slightly in one direction or the other, depending on which direction the slide is traveling. There is no longitudinal movement of the stop rod, and it is supported on ball bearings for the rotating movement. The feed motion is derived from this partial rotation of the shifting mechanism. The adjustable feed crank is geared with the stop rod and partakes of this motion, giving it in turn to a ratchet feed of the usual construction at the end of the feed screw on the cross rail. The head has a down feed of 6½ inches. The swivel is graduated and is provided with a micrometer collar reading to 0.001 inch. The table is raised and lowered by means of a crank handle, not shown, and is provided with a supplementary table at one side, as may be seen from the cut. This supplementary table may be removed so that the work may be bolted against the side of the table proper, or the whole table may be removed, when pieces may

be fastened directly to the column. All flat bearings are hand scraped to surface plates, and all T-slots are cut from the solid.

The size shown, 15 x 30 inches, has a net weight for the machine and countershaft of 3,450 pounds. The ratio of cut to return is 1 to 2. The length of the table with the extension is 30 inches, and it has a width of 18 inches and a depth of 12 inches. The Cincinnati Shaper Co., Garrard Ave. and Elam St., Cincinnati, Ohio, are the builders.

THE BRIDGEPORT GEARED MOTOR DRIVEN TOOL GRINDER.

The Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn., have placed on the market the geared motor driven wet tool grinder shown in the cut below. As may be seen, the motor is mounted on a shelf cast to the base of the machine, and is connected to the wheel spindle through gearing in the ratio of 3 to 1. This arrangement runs very quietly; the gears are carefully cut, are encased to exclude dust and grit, and the bearings are self-oiling. The machine can be started up when the power starts in the morning and run as long as the shop does if desired, avoiding the need for starting and stopping the machine each time it is used. Any motor required by the customer can be fitted to this machine. The No. 5 size here shown takes a 5 horsepower motor. The bearings are 8 inches in length. The emery wheel used is

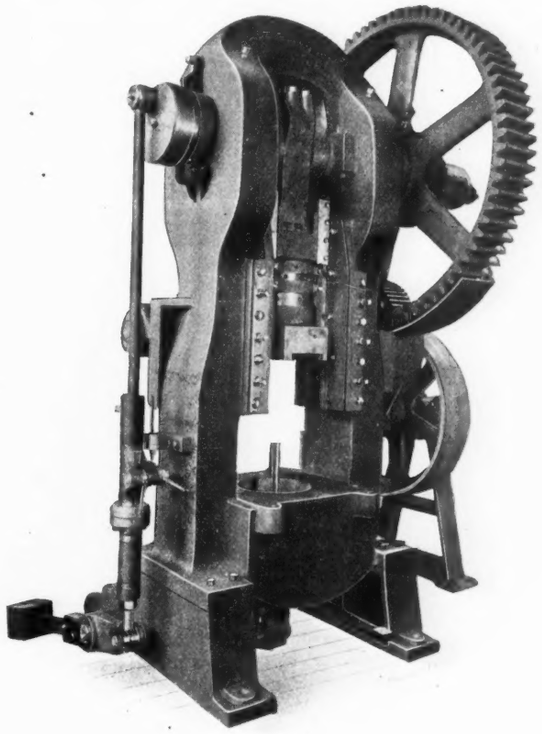


A Geared Motor-driven Tool Grinder.

36 inches in diameter with a 4-inch face, and the machine occupies a floor space of 30 x 47 inches. The wheel runs at 425 revolutions per minute. The weight of the machine with the motor is 2,650 pounds.

A LARGE SINGLE CRANK PRESS.

The E. W. Bliss Co., 5 Adams St., Brooklyn, N. Y., have recently completed the largest single crank press ever built in their shops. The constant demand for increased size in the product of power presses has necessitated a constant growth in their dimensions. The press we show is one that would a few years ago have seemed of abnormal size—beyond the capabilities of the makers to build or the purchaser to use. It is now, however, simply an unusually large machine of a well-known type, with the addition of certain improvements in detail which adapt it more nearly to the work it has to do. The machine is double geared, with an automatic jaw clutch on the crank shaft as in smaller presses. This clutch is positive in its action, and is silent whether in operation or not. The ratio of the gearing is 25 to 1, and the entire train is made from steel castings with the teeth cut from the solid. The large gear is 80 inches in diameter by 10 inches face and weighs 4,500 pounds. The arrangement is such that the gearing will not interfere with the operator in work that requires his attendance at the rear of the press. The knockout, which is plainly shown, is operated from a crank at the left-hand end of the crankshaft. It is adjustable for length by means of the stop screw and lock nut in the projecting bracket at the lower left-hand side of the frame; this operates a releasing mechanism in the knockout connecting rod and limits the upward movement, which is thus adjustable to any point



Bliss Single Crank Press of Unusual Size.

required. Through a crank and rock shaft the knockout motion is carried to the vertical plunger in the center of the bed, where it is applied to the parts provided for removing the work from the die. The crank operating the knockout is held to the shaft by a ratchet disk, which allows it to be shifted in any angular position to suit the requirements of the work being done. This adjustment is in addition to the variable stroke obtained by the releasing mechanism just described. The slide has an unusually long bearing in the frame and is scraped to it; the pressure strain comes against solid metal rather than against the gibs which are provided to take up the wear. A vertical adjustment of 3 inches in the slide is obtained by a screw 18½ inches in diameter. This screw is made with a flat thread on the pressure side, thus preventing all side strains.

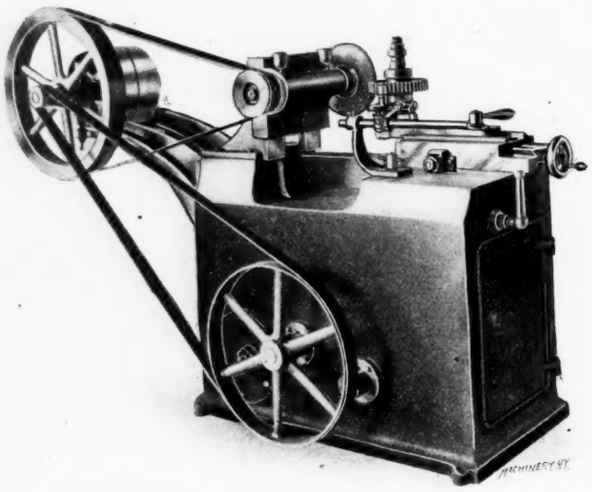
An idea of the size of this press may be had from the following facts: The frame is a solid casting and weighs over 18,500 pounds. The area of the bed is 31 inches by 32 inches. The distance from the bed to the slide with the work and adjustment up is 30 inches. The shaft is 9 inches in diameter and has a 12-inch stroke. The flywheel is 50 inches in diameter by 10 inches face and weighs 2,500 pounds, making 250 revolutions per minute. The total height of the press is 12 feet 9 inches, and the total weight is something over 41,000 pounds.

A FINISHING GRINDER FOR CAST GEAR TEETH.

The machine which we illustrate herewith is for a somewhat unusual purpose. Immense quantities of cast gearing are used in agricultural and textile machine and other products of that kind, a field in which the cut gear has as yet made little impression. Cast teeth are on the whole made more accurately and smoothly than ever before, but it is still necessary to resort to the file and cold chisel very often in preparing the gear castings for service, as fins and lumps are liable to occur on the tooth faces of even the best work of this kind. To perform this operation automatically Messrs. Upton & Gil-

man, of Lowell, Mass., have devised the automatic gear grinding machine here shown.

The gear blank is mounted on a vertical arbor in a slide on top of the bed. The grinder wheel is presented to the work on a horizontal axis held in a vertical reciprocating slide whose travel may be adjusted from 0 to 5 inches. A quick return crank motion is provided for this. While the grinding wheel is returning to commence a new stroke, the mechanism within the base of the machine withdraws the work, indexes it, and again presents it to have a new tooth smoothed off.



Machine for Smoothing the Teeth of Cast Gears.

The working parts are all so far as possible carried inside of the base, where they are protected from the grit of the emery wheel. The capacity of the machine is for spur gears from 4 to 36 inches in diameter and up to 4 inches in face. Its weight is about 2,200 pounds. The original machine has been successfully run in one of the largest shops in Lowell for several years and has proved its usefulness and durability. To this shop the makers will be pleased to refer inquiry.

A HEAVY NEWTON SLAB MILLER.

With the considerable increase in the size of machinery of various descriptions, especially in the case of locomotives, on which there is a great deal of forging and other steel work; with the growth of the modern practice of forging roughly and depending on the finishing process to bring the forging to shape and in condition to use; and with the demand for the greater strength and stiffness required by high speed steels, the weight, power and rigidity of the heavier machine tools such as slab milling machines, for instance, has been increased to a remarkable degree. The miller shown in the accompanying cuts, built by the Newton Machine Tool Works, Inc., Philadelphia, Pa., reflects very plainly the influence of the considerations just enumerated. In fact, the builders believe that they have successfully discounted the severest conditions likely to be met with in service.

The spindle of the machine shown is 6½ inches in diameter and has a main bearing 15 inches long; it is driven by a phosphor bronze worm wheel and a casehardened worm of steep lead, provided with a roller thrust bearing, and is positively geared to a 35 horsepower 2 to 1 variable speed motor. The driving worm and worm wheel have a ratio of 20 to 1. The spindle has an 8-inch adjustment lengthwise (that is to say, across the table of the machine) for convenience in setting the cutters after the work has been located on the platen. To permit this the spindle is driven from the worm wheel by a double spline. The arbor is driven by a "butterfly" key, it being provided with a tongue on the face of its collar which engages the groove milled across the front end of the spindle. The outboard bearing for the arbor is bushed; the bushing is tapered on the outside and split to allow adjustment for wear. It is arranged to fit over the arbor bushings and to be adjusted to support the arbor close up to the work. The cross rail on which the main and outboard spindle bearings are attached has an inclined face bringing the bearing surface normal to the resultant pressure caused by the rotation of the cutter and the feeding of the work. This does away with the tendency of the tool to pull in or gouge into the work.

The main upright has a bearing surface 25 inches wide while the outboard bearing has a face 12 inches wide; the length of the bearing of the cross rail on these two uprights is respectively 38 inches and 31 inches. This gives some idea of the ample proportions followed in designing the machine. The cross rail is counterweighted, has hand adjustment with quick power movement in both directions, and its power movement is so designed as to be available for sinking the cutter to the required depth by power. The makers believe that this is a new feature. To permit this the elevating screws are arranged to pull the cross rail down into the work instead of pushing it as in other designs, this arrangement overcoming the tendency of the cross rail to rise. Besides being a great time saver, this feature overcomes the chief difficulty previously experienced in fluting locomotive connecting rods, where it is necessary to sink the cutter to a depth of from 1½ to 1¾ inch in the rod. In connection with this a provision is made to prevent the table from pulling forward when sinking in, thus overcoming the breaking of cutters and arbors and the consequent damage which results from this cause and from the upward spring of the cross rail. The fact that the center of the spindle is 4 inches below the lower edge of the cross rail makes the machine convenient in working around oil cup bosses on locomotive connecting rods, and in sinking in and milling keyways on shafts of large diameters having collars and projections of considerable size. The table, which is gibbed to the outside of the bed, is driven from the motor through positive gearing entirely. The feed provided gives from 1 to 10 inches per minute with quick power movement in either direction, obtained through a compact gear box easy to control and more rigid in construction than any that has yet been designed for this work. Sliding gears are used,

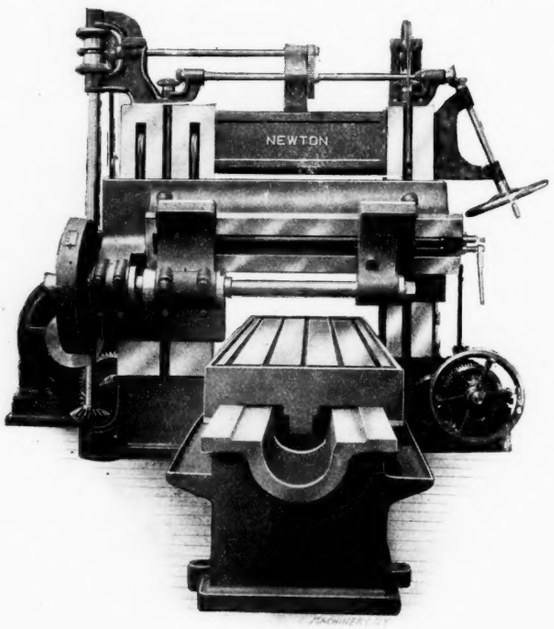


Fig. 1. Front View of Newton Slab Miller.

the contact edges of the teeth being beveled so that the change can be readily made while the machine is running. From this gear box motion is transmitted to a bronze spiral pinion on an angular shaft meshing with a steel rack 4 inches wide on the under side of the platen. The gears in the gear box are all of steel and run in oil.

In actual service for something over six months, the time maintained for two different jobs (of which large quantities have been performed) are as follows: In a milling cut with a width of 9½ inches and a depth of cut of 9/16 inch a linear feed of the platen has been maintained at 8 inches per min-

ute, giving a removal in chips equal to 43 cubic inches per minute, or about 1¼ cubic inch per minute of rated horsepower. The makers believe that this extraordinary record is in part due to the rigidity and weight of the machine, and in part to the worm drive. The Newton Machine Tool Works have been using the worm drive for many years, and to them is due a large share of the credit for the change of opinion which has lately taken place in favor of this method of transmitting power. In fluting or channeling locomotive connecting rods, doing two at a time, a cut is taken 3 inches wide and 1½ inch deep, the feed of which is 3¼ per minute, this making a section of 9 square inches being removed at the feed just given. The figures given above have been maintained on this work for some time past. The cutter used is of the inserted tooth type, the teeth being of air-hardened steel inserted on a true helix. The cutting speed is about 86 feet per minute at the periphery of the cutter.

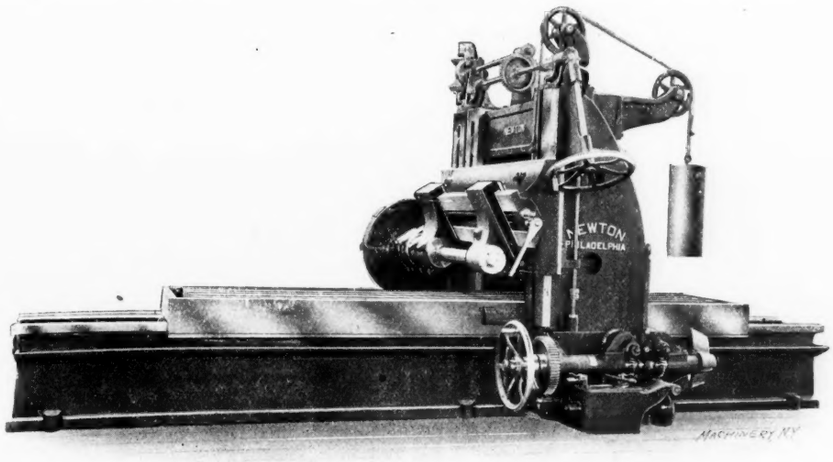


Fig. 2. Side View of Newton Slab Miller, showing Feed Mechanism.

ALTENEDER'S DRAFTSMEN'S PEN-FILLING INK STAND.

Since the discarding of the old-fashioned process of grinding India ink as fast as it is used, the troublesome question has arisen of where to put the ink bottle so that it may be safe from overturn and still be convenient. To provide a bottle holder that will be both safe and convenient, and in addition to that, to provide a means for filling the draftsman's pen very much more quickly and easily than it can otherwise be done, Theo. Alteneder & Sons, of Philadelphia, have devised the ink stand shown in Figs. 1 and 2.

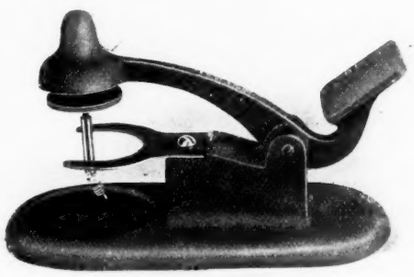


Fig. 1. The Alteneder Pen Filler and Ink Stand.

The first of the two halftones gives an idea of the construction of the device. The cast-iron base is sufficiently heavy to supply the element of stability, an element whose need is strongly felt when working with a bottle unprovided with a holder. This base is designed to receive and securely hold the standard bottle now in general use. The forked spring shown surrounds the neck of the bottle and holds its base firmly within the recess provided for it. Pivoted to the frame at the rear end of the device is a lever with a rest for the palm of the hand at one end, and a stopper and pen filler at the other. The stopper is a disk of soft rubber, held down over the mouth of the bottle by the weight of the lever to which it is attached. Experiment has shown that this arrangement is as efficient in preventing evaporation as is the cork now in use. The pen filler or "dipper" consists of a coiled spring fastened at the end of a stem projecting down from the end of the lever through the rubber cap. Three or four of the lower coils of this spring are pulled away and bent slightly to the rear of the upper portion, while the lowermost loop is turned at right angles to its normal position, in a way which cannot be easily described, but which works beautifully in actual use. This little arrangement is adapted to picking up and holding a sufficient amount of ink for one filling of the pen, this ink being immediately released when contact is made between the lower loop of the spring and inside of the nibs of the pen.

In inserting a bottle in this holder, first remove and discard the stopper and quill which come with it. With the right hand placed on the rest, raise the dipper and hold it at the limit of its upward movement, then with the left hand insert the bottle in the recess under the spring. If, after the bottle has been inserted, it is found to be so much shorter than the average that the dipper touches the bottom and holds the rubber cap away from the mouth, shift the cap to a lower groove on the dipper stem. Three of these grooves will be found. This should also be done when the dipper is found to be picking up sediment. In using the ink stand, place it on the drawing board within easy reach, slightly to the right and with the name-plate end nearest the body, as shown in Fig. 2. With the point held precisely as when ruling a line, place the hand on the rest, depressing it and holding it firmly at the limit of its movement; then bring the point directly under the dipper. Raise the point until the dipper loop has entered between the blades, and move the hand slowly so that the loop will just touch the blades, when the pen will fill instantly. Without trying to draw the loop through the blades, lower the pen, move it one side and take the hand from the rest, when the cap will descend and close the bottle. The entire operation consumes less than five seconds.

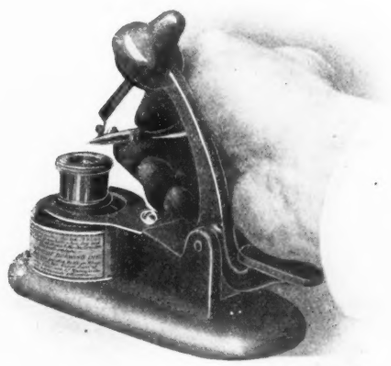


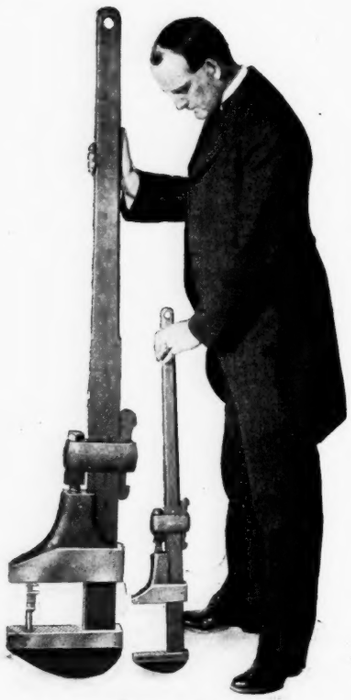
Fig. 2. The Pen Filler in Use.

The advantages claimed for the device are: a saving of time in filling the pen; a certainty in the amount of ink delivered each time the filler is used; safety and convenience in holding the ink bottle of standard form; provision of an automatic stopper; efficiency in preventing evaporation; and the

avoidance of the necessity of using more than one hand in filling the pen, leaving the other one free to hold the T-square, triangle, or other instrument being used.

THE LARGEST SCREW WRENCH YET MADE.

One would scarcely expect that any practical use would be found for an adjustable screw wrench of as great size as the largest one shown in the cut below, yet there has been a sufficient demand for a tool of this magnitude to induce the Coes Wrench Co. of Worcester, Mass., to undertake its manufacture. The wrench is of their T-model pattern, which provides a quick adjustment to two or three different positions, after which the final tightening is accomplished by a nut in the usual manner. This wrench is 72 inches in length. An idea



Three Members of the Coes Family of Screw Wrenches.

of its great size is obtained in comparing it, on the one hand, with the stature of Mr. Coes who holds it, and on the other hand with the smallest size wrench of the Coes line, which it held between its jaws. This series of key wrenches is made from steel forgings and steel castings throughout, all the parts being hardened.

The use to which this tool is put is in the tightening of the large nuts used in bridge construction. It was built in response to inquiries from bridge-building companies, and it was concluded, from the nature of the inquiries, that a tool of this size would be required to meet extreme conditions. The wrench has a full jaw opening of 12 inches with a depth of 8 inches. The jaw weighs 33½ pounds, the screw weighs 8½ pounds, the bar 114 pounds, and the total weight is 160 pounds. The complete line now includes 28-inch, 36-inch, 48-inch and 72-inch sizes. The 36-inch size, shown also in the cut, has been found especially useful for opening hopper-bottom cars, and many have been sold for that purpose.

* * *

Water-proof glue is manufactured of gum shellac, three parts and India-rubber, one part by weight, these constituents being dissolved in separate vessels in ether, free from alcohol, subject to a gentle heat. When thoroughly dissolved, the two solutions are mixed, and kept for some time in a vessel tightly sealed. This glue resists the action of water, both hot and cold, as well as most acids and alkalis. If the glue is thinned by the admixture of ether, and applied as a varnish to leather along the seams where this has been sewn together, it renders the joint or seam water-tight, and almost impossible to separate.—*Scientific American.*

EUROPEAN INDUSTRIAL NOTES.

PRESENT CONDITION OF BRITISH MACHINE BUSINESS.

It is perhaps superfluous to state that, speaking generally, business over here in the engineering and tool-building lines is booming. At the same time it cannot be said there is any particular symptom of feverish "hustling." People are, so far as the available supply of competent men allows, working their plants as many hours as they think pay, and extending their equipment as current deliveries of tools and considerations of prudence permit. After doing this they cease worrying, knowing everyone else is too busy to do them much harm. Looking back, say about six or eight years, it is interesting to note how the jeremiades then more or less current as a result of loose journalistic generalizations have been falsified. Far from foreign competition extinguishing any really staple industry, most have only been revitalized as a consequence of investigation into weak spots thus caused. It is almost safe to say the lessons the United States then had to teach have been taken to heart with comparatively little whining, and so gradually utilized that shop practice has, almost unconsciously, undergone a virtual revolution.

In the tool trade, the Taylor-White steel demonstration at Paris in 1900 found the British makers at some advantage over the Americans, as most of their (the British) tools had more "weft" in them than the American ones, though less handy in some particulars. Following up this fortuitous circumstance, they have easily kept pace with the advances in high-speed steel, and have seldom been confronted by really serious competition in the heavier branches. At the same time, the undoubted merits of the best class of American tools have met, and still meet with, the heartiest recognition on the part of British users, as shown by the fact that deliveries of this class of machinery are spoken for, in some cases, eighteen months ahead. Incidentally, it may be stated that any first-class American tools which by any means come to auction or forced sale, are as eagerly picked up as though new, but much of the rubbish sent over here at the time of the cycle boom is now to be found in marine store dealers' establishments, drifting toward the scrap heap.

The system of confining productive energies to a comparatively limited variety of machinery has made rapid advances, coincidently with the fact of several American concerns broadening out in the direction of greater variety. Even where strict specialization is not—probably for good reasons—over-favorably viewed, tools are produced in larger batches at a time than formerly, thus allowing a greater net profit or productivity than might perhaps be expected. Further, travel in the States and on the Continent of Europe on the part of works proprietors, managers, business men, and, to a greater extent than perhaps imagined, workmen, has tended to rapid assimilation of cosmopolitan methods, a process assisted to a not inconsiderable extent by the spread of technical education in various forms. On this side, some of the old-established concerns hold a very strong position as regards the supplying of heavy tools for ordnance purposes, and this position has been further strengthened since the building of large steam turbines called for tools of extremely wide range. Then, again, the automobile industry, which is advancing in a remarkable manner, has enormously stimulated the demand for high-class tools of medium and light weight, in addition to encouraging cognate industries in the way of driving chains, roller and ball bearings, milling cutter manufacture, gear-cutting specialization, etc. Concurrently with these developments, gas engines of large power—utilizing blast-furnace and producer gas—are being built in increasing numbers, and the manufacture of electrical plants of most classes is now firmly established in this country, another circumstance explaining the present condition of affairs in the tool shops. An interesting sequence of these developments is the diminution of output of former types of "merchant" tools which were built with low first cost as the sole motive of production. Users of every degree of familiarity with tool practice are so well posted comparatively that selection of plant is now accorded more intelligent consideration, and the demands the toolmaker has to meet become correspondingly more exacting. A noticeable feature at the moment is the

tendency of manufacturing industries to leave the neighborhood of London for localities where land, rates, taxes, and labor are cheaper, and the increasing alertness of local governing bodies in the matter of encouragement of such migration. A movement is also afoot, in the form of "Garden Cities" associations, to create industrial communities in which manufactures may be carried on with a minimum of objectionable features, and the maximum of healthful and pleasant living and social conditions. Another form of industrial association, originated in this country, touches the cotton industry directly, and thus, practically every other industry. The organization alluded to is the "British Cotton Growing Association," formed, as a consequenece of the last attempts to "corner" American cotton, for the purpose of encouraging the growth of cotton, primarily in the British empire, and secondly in other portions of the two hemispheres. This beginning has led to combined action of all the European cotton-using countries to enlarge the sources of supply of the raw material, and thus circumvent and minimize the activity of parasitical cotton speculators. This association is supported by employers, work people, and government colonial departments, and can point to very definite results already. It is a rather ironical fact that a committee of the association is about to visit the United States with a view to formulating a report on the possibilities of the improvement of cotton growing, harvesting, packing and shipment. It may be news to many that American cotton is packed and shipped in the most slovenly and wasteful manner of any in the world. Egypt and India are miles ahead in this matter.

The immediately preceding remarks may appear to have little bearing on the machinists' and toolmakers' business, but, more probably than any other class, are the people interested in these branches of work influenced, favorably or otherwise, according as the raw materials of industry are, or are not, available in sufficient quantity at the right price and right time. In a further letter I hope to give some details of British activity in toolmaking and engineering generally.

Manchester, Eng., November 23, 1906. JAMES VOSE.

THE AUTOMOBILE INDUSTRY OF ITALY IN 1906.

The automobile industry in Italy, though dating only from five years ago, continues to develop and increase in importance so rapidly that it is recognized and valued as one of the larger industries of Italy. Great strides have also been made in the mechanical arts, especially in the manufacture of machine tools. Official statistics of the automobile industry in Italy are as yet few, but it is very instructive to note some returns published lately by the eminent engineer, Prof. Effen Magrini.

From these may be seen that previous to the year 1905 there were only nine manufacturers of automobiles in all Italy, with a total effective capital of about 85,000,000 francs (17,000,000). During the year 1905 this number was increased by twenty-five with a capital of 45,000,000 francs ($9,000,000), and in the first six months of 1906 seventeen more companies were founded with an effective capital of about 100,000,000 francs ($20,000,000).

Over and above this must be counted the carriage manufactories, which in July, 1906, numbered 19 with a capital of about 24,000,000 francs ($4,800,000), and the other industries connected with automobiles, such as the manufactories of chassis, lamps, lubricators, tires, brakes, etc., the garages for testing and repairing, amounting to 30 firms, with a capital of about 24,000,000 francs ($4,800,000).

Examining the number and value of the automobiles imported and exported in the last five years, we find that from 1900 till 1903 the imports were 1,070, with a value of 8,402,548 francs ($1,680,510); in 1904 the imports were 410, with a value of 4,110,860 francs ($822,172); and in 1905 the number imported was 667, with a value of 6,239,000 francs ($1,247,800). For the present year, 1906, it may be safely assumed that the figures will be: 1,200 automobiles imported, corresponding to the sum of 12,000,000 francs ($2,400,000).

With regard to the automobiles exported, the figures are: From 1900 to 1903, 98, with a value of 894,750 francs ($178,950); in 1904, 127, value 1,112,560 francs ($222,512); in 1905, 287, value 3,646,000 francs ($729,200); and this year the number exported will be about 462, with a value of 6,450,000 francs ($1,290,000).

After France, the United States does the largest trade with Italy in the automobile business; in the year 1904, for example, of 410 automobiles imported in Italy, 304 were from France, 48 from the United States, 43 from Germany, and 15 from other European countries. Of 126 exported, 70 were sent to France, 24 to the United States, 15 to Austria-Hungary, 7 to South America, and the remainder to other parts of Europe, Asia and Africa. Perhaps we may account for active business relations between Italy and the United States in this branch of industry by the great demand in the Italian market for American machine tools. I. E. T.

Milan, Italy, December 1, 1906.

MISCELLANEOUS FOREIGN NOTES.

HIGH-TENSION CONDUCTORS.—At the Milan exhibition experiments were undertaken with insulated cables manufactured by Pirelli & Co., Milan. These cables were tested to breakdown, which occurred at voltages varying from 208,000 to 210,000 volts. Pirelli & Co. claim to be the first makers of cables for commercial use intended to withstand such high pressures.

THE MACHINE TOOL TRADE BUSY AND PROSPEROUS IN GERMANY.—According to *Zeitschrift fur Werkzeugmaschinen und Werkzeuge*, the German machine tool builders are very busy at the present time and the business is in a prosperous state. In many places it has been necessary to work overtime even during the summer months, although this has sometimes met with objections on the part of the men. Wages have increased from 10 to 25 per cent, due mainly to the increasing difficulty of securing skilled help.

THE ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT, with works at various places in Germany, reports for the year ending June 30, 1906, a growing business. The total capital has been increased by $3,500,000 to $25,000,000, on which, for the past year, a dividend of 11 per cent is proposed. The output of machines, electromotors and transformers was numerically greater by 34 per cent than in the previous year, the increase reckoned in kilowatts was 26 per cent, and in value the receipts were greater by about 20 per cent. The total number of the employes was 33,906, as compared with 30,366 in the previous year.

WEBSTER & BENNETT, LTD., Coventry, England, have recently brought out a two spindle high speed drilling machine intended for drilling holes with small center distance. The machine is designed for obtaining the maximum work from ½ inch to 1½ inch high-speed drills. The minimum center distance between the spindles is 4 inches, and the maximum distance 18 inches. The maximum distance between the spindle and the table is 24 inches. The spindles are fitted with a No. 4 Morse taper. The table is of the usual form for this class of machines with T-slots on the top as well as on the vertical front face. The table is 24 inches square, and the height of the vertical face is 20 inches. The two spindles are independent as to drive and feed.

JOHN LANG & SONS, Johnstone, N. B., have brought out a 36-inch facing and boring lathe fitted with their patent variable speed drive and automatic speed changing mechanism. With these in operation, when facing work, such as cylinder covers, faceplates, etc., the revolutions of the spindle automatically increase as the diameter being turned becomes smaller. The hexagon turret is fitted for carrying ordinary or special tool holders. The self-acting feed motions are positive and four different feeds may be had without stopping the lathe. When specially ordered eight feeds may be provided which can be thrown in without interrupting the work on hand. The standard feeds per revolutions of spindle are 1/4, 1/8, 1/12 and 1/16 inch. The approximate floor space required is 12 x 5½ feet.

IMITATION OF DAMASCUS GUN BARRELS BY BELGIAN MANUFACTURERS.—According to a report from Consul J. C. McNally, Damascus gun barrels are imitated so closely by Belgian manufacturers that the imitation is very difficult to detect. The manufacturers in practicing this deception use silk paper, and by

means of a decalcomania transfer, this design is attached to the plain barrel by the use of certain acids and processes which are kept secret. It is almost impossible for any one not thoroughly familiar with the manufacture of these guns to distinguish between the real and the imitated Damascus barrel. In order to make a test it is necessary to erase the design. If an imitation, the design cannot be restored, but if the Damascus is genuine the application of sulphuric acid will immediately bring out the original design. According to the consular report 200,000 barrels are annually manufactured with this imitated design. Most of them are sent to the United States and to South America. Double-barrel shot guns are usually the only kind thus imitated.

AMERICAN MACHINE TOOLS IN GREAT BRITAIN.—Consul Albert Halstead, of Birmingham, advises that the market for standard American machine tools gained in the United Kingdom and the Continent through their superior excellence, is threatened, chiefly because of the inability of American manufacturers to make reasonably early deliveries. Because of the present long delays in filling orders for American machine tools, British manufacturers are, to a large extent, buying tools that can be delivered immediately. British tool makers, who have heretofore pushed their own designs, noting the inability of American machine tool makers to fill orders promptly, as well as the financial success of several British firms in copying American tools, are now spurred on to make tools on American models. The delay in the delivery of any reputable American lathes and milling machines averages now from three to six months. Until quite recently these tools were kept in stock and a delay of six weeks was unusual. The delivery of universal milling machines is now made in from six to nine months and gear-cutting machinery often cannot be obtained under twelve months. When they cannot be assured of getting standard American machine tools promptly, British and other foreign manufacturers buy those they can secure as soon as ordered. If such substitute tools work well, they will naturally order similar tools when they require more, which means permanently lost trade for the American tool builder. Every machine tool-making industry in the United Kingdom is reported to be overhauling its patterns and bringing them up to date; in short, the British tool makers are Americanizing their tools.

* * *

OBITUARY.

Henry J. Hendey, president of the Hendey Machine Co., Torrington, Conn., died at his home in that town December 8 after an illness of several weeks with a complication of diseases, principal of which was nervous exhaustion. Mr. Hendey was born in London, England, December 29, 1844. He came to this country with his father in 1858, and located at Waterbury, where he learned the machinist's trade. In 1865 he went to Torrington (then Wolcottville) and entered the employ of the Turner & Seymour Co. as a machinist. In 1870 Mr. Hendey in company with his brother Arthur started in business for himself in a small machine shop on Litchfield Street. The motive power of the shop was a small rotary steam engine of three horsepower which had been built by Mr. Hendey for amusement. The engine has been carefully kept and is now to be seen in the power plant of the Hendey Machine Co. alongside of the 500-horsepower Harris-Corliss compound engine driving the present shop. At first the business of the brothers in the original 18 x 24-foot shop was principally repairing machinery, but they soon began building planers and other machine tools, and in a few months the work had increased so that they employed one man and a boy. In 1871 the brothers removed to part of a factory known as the East Branch spoon shop, and later, in 1874, the Hendey Machine Co. was organized with a capital stock of $16,000. A factory was built on the present site near the Coe Brass Works. The growth of the business of the company has been rapid, both in the United States and abroad; the Hendey-Norton lathes are favorably known wherever machine tools are used. The shops are modern, up-to-date structures, with electric drive throughout, and about 600 men are now employed. In the early part of their career the company built planers, but the planer business is now discontinued, and the product is confined to lathes, shapers and milling machines, the milling machine having been added to the product a few years ago. The present capital stock of the company is $300,000. Mr. Hendey had been president of the Hendey Machine Co. since 1883.

Mr. Hendey was prominent in the local affairs of Torrington; he was the first warden of the borough and afterward served as burgess. Later he was elected a member of the State Legislature, where he was made one of the committee of manufactures. For many years he had been a senior warden of Trinity Church, and he was a past master of Seneca Lodge,

Henry J. Hendey.

No. 55, F. & A. M. Until only recently he took an active part in the local affairs, and always stood for those things which helped to make the community stronger and better. His way of looking at public matters was broad and just. The struggles of his early life developed within him a vigorous habit of thought and action, but no inclination toward anything except absolute justice. Mr. Hendey was a great lover of his home and found there the principal source of the joy of living.

Arthur R. Jones, superintendent of the American & British Mfg. Co., Bridgeport, Conn., died suddenly October 11 after a few hours illness. Mr. Jones was about forty years old and was born in Willimantic, Conn.

Henry C. Clark, president of the Clark Bros. Bolt Co. and the Aetna Nut Co., Southington, Conn., died December 4 of pneumonia at the age of 78. Mr. Clark was one of the pioneers in the bolt and nut business.

Wallace J. Johnson, for the last twenty years with the Niagara Falls Hydraulic Power & Mfg. Co., died at Niagara Falls, December 15, at the age of 50 years. He was born in Granville, Mass., and was a well known civil and hydraulic engineer.

Edward Payson Bullard, Sr., president of the Bullard Machine Tool Co., died suddenly December 22 at Braidentown, Florida. He left Bridgeport December 19 in apparent normal health for his regular Southern trip. A biographical article on Mr. Bullard will be published in a later issue.

B. H. Warren died of apoplexy October 20, in New York City. He was at one time vice-president of the Westinghouse Electric and Manufacturing Co., and later president of the Allis-Chalmers Co. Upon his retirement from the latter company he entered into consulting work in company with Messrs. Kafer and Mattice in New York.

* * *

PERSONAL.

Frank H. Taylor has been elected vice-president of the Yale & Towne Mfg. Co. Mr. Taylor was formerly vice-president of

the Westinghouse Electric & Mfg. Co. and is still a director of that company.

Henry G. Judd, for five years secretary and superintendent of the Mattatuck Mfg. Co., Waterbury, Conn., has resigned to become superintendent of the Noera Mfg. Co., of the same place.

On January 1 Mr. H. H. Lane, who has been editor of *The Foundry*, since October, 1903, will sever his connection with the Penton Publishing Company to engage in the practice of consulting foundry engineering with headquarters in Cleveland. Mr. Lane also expects to have New York connections, and will be in a position to advise on all classes of foundry construction and foundry metallurgy, including gray iron, steel and malleable. He will continue his position as secretary of the Foundry Supply Association for the present, and devote a much larger amount of his time to the work of the association than would be possible under the former management. This will redound to the success of the convention of the American Foundrymen's Association in Philadelphia, May 20 to 24 next. Mr. A. O. Backert, formerly Pittsburg editor of *The Iron Trade Review* and later western editor of *The Iron Age*, with headquarters in Chicago, will succeed Mr. Lane as editor of *The Foundry*. Mr. Backert has had a wide acquaintance among foundrymen, and was prominent in the work of the Pittsburg Foundrymen's Association for several years.

* * *

THE VALUE OF HAVING A FIRM NAME WELL-KNOWN.

In these days of advertising generally by concerns in all sorts of businesses, one is occasionally found which conservatively holds to the old idea that the best kind of an advertisement is a satisfied customer. While this idea is true enough, it has the fault of not being the whole truth. The satisfied customer does not usually go about the country drumming up business for the firm which filled his orders, although he may recommend it, perhaps, whenever occasion seems fit. Parenthetically we might remark, however, that a satisfied customer is usually quite willing that any competitor shall remain very much in the dark about the source of his machinery or other equipment if it can be conveniently concealed, and so far as "blowing a horn" for the builders of such he is more likely to discourage all inquiries. We speak from knowledge in view of our experience oftentimes in trying to get the names of builders of special machinery. As regards advertising it is worth much for any concern to get its name so well established that it can scarcely be quoted incorrectly. Bearing on this point, we recently published a short article describing a piece of engineering work done by a concern which claims to believe that doctors, lawyers and engineering concerns should follow about the same code of ethics, *i. e.*, depend upon the drumming for business done by their friends. Unfortunately and very much to our own vexation the name of this concern was given incorrectly. That it was given incorrectly is not so surprising, for we are unable to find in any publication coming into this office an advertisement containing the name of the concern in question although it is a fairly well-known institution in a restricted field. The point to be made is that while we were not by any means entirely dependent upon memory for the correct name we depended upon it in the absence of more convenient reference and this proved to be faulty, and the same mistake might have happened with a prospective customer. That this slip could have happened with one of many other engineering concerns which have followed a liberal policy in the matter of advertising is scarcely possible. How such desirable publicity shall be obtained is a matter that has to be decided individually.

* * *

FRESH FROM THE PRESS.

HISTORIC LOCOMOTIVES. By Alfred R. Bennett. 36 pages, 9¾ x 13½ inches. 10 full-page plates. Published by Castle & Co., Ltd., London, England, and Derry-Collard Co., New York. Price, $1.00.

The book describes and illustrates the Great Western Railway Co.'s broad-gage engine "Great Western"; London & South-Western Railway Company's four-coupled engine "Milo"; London, Brighton & South Coast Railway engine No. 122; Caledonian Railway 8-foot single driving wheel engine No. 83; Bristol & Exeter Railway Co.'s 9-foot driving wheel broad-gage engine No. 42; North British Railway engine No. 224; London, Brighton & South Coast engine No. 111; London & North-Western Railway engine "Prince of Wales" No. 291; outside cylinder Crampton locomotives and inside cylinder Crampton locomotives, South-Eastern Railway. The plates are gorgeously colored, the like of which we are inclined to say "was never seen on land or sea," but the author assures us that the colorings are faithful reproductions of the originals. As a picture book it will undoubtedly attract considerable attention, but to the practical railroader it has little interest.

SWITCHBOARDS. By William Baxter, Jr. 192 pages, 5½ x 7½ inches. 150 illustrations. Published by the Derry-Collard Co., New York. Price, $1.50.

The importance of the switchboard in any electrical plant is so obvious that it is unnecessary to dwell upon it. The book in review is intended to be a practical description of the instruments, their method of connection and location; the things to be avoided; how to connect machines; how to balance on the three-wire system; connecting in parallel; and the many other features connected with the switchboard which have to do with the operation of a power plant. The work is profusely illustrated with drawings and half-tones and is written by one who by many years of practical and theoretical experience is well qualified to write a book of this character. His writings have the characteristics of lucidity of style and clearness of meaning which make them very popular with the class of readers to whom this book will appeal.

PRACTICAL METAL TURNING. By Joseph G. Horner. 404 pages, 5½ x 8 inches. Illustrated with 488 cuts. Published by Norman W. Henley & Son, New York. Price, $3.50.

This work is the same as Engineers' Turning, reviewed in this column in October, 1905. It is intended to be a compendium treating in a comprehensive manner on the modern practice of machining metal parts in the lathe, including the engine lathe, its tools, attachments, manner of holding the work and performing the operations. It is decidedly British in its tone, as would naturally be inferred from the authorship, and the fact that the work was originally published in Great Britain by Crosby Lockwood & Son, London; Norman W. Henley & Son, New York, have brought out an American edition, believing that it will meet with favor among a considerable number. It is a work of value containing as it does much practical instruction and many good shop kinks for apprentices and journeymen machinists. The style is clear and simple; the book is gotten up in substantial style, well printed and well bound.

WALSCHAERTS LOCOMOTIVE VALVE GEAR. By W. W. Wood. 193 pages, 5 x 7 inches. Illustrated with 36 cuts and diagrams with two separate cardboard models of valves in pocket of book. Published by Norman W. Henley & Son, New York. Price, $1.50.

The book is composed of four general divisions, the first of which explains and analyzes the Walschaerts valve gear; the second takes up designing and erection; the third has to do with the actual work of the Walschaerts gear; and the fourth section is composed of questions and answers in the popular catechism style. The wide interest at the present time in the Walschaerts valve gear, due to its introduction in American locomotive construction, makes the appearance of this book timely, and it should meet the wants of a considerable class of railroad men who are looking for a practical work on the subject. The folding diagrams with cardboard valve models, by which the actual operation of the valve under the influence of the Walschaerts motion can be studied, is a novel and interesting feature.

TOOLS FOR MACHINISTS AND WOODWORKERS. By Joseph G. Horner. 340 pages, 5¼ x 7¾ inches. 406 figures. Published by Norman W. Henley & Son, New York. Price, $3.50.

The object of this book is to comprise a general description and classification of cutting tools, together with modern instruments of measuring. It takes up tool angles, and gives considerable space to the conditions affecting the cutting action of woodworking tools, including knives, chisels, planes, etc. Then follow scraping tools, tools related to both chisels and scrapers, percussion and molding tools, hardening, tempering, grinding and sharpening tools for measurement and testing, etc. Mr. Horner is a well-known English writer on technical subjects; he has done an enormous amount of this kind of work for various English technical publications and in books of his own. The work is gotten up in attractive style and will no doubt interest a large class of amateur readers who desire information on the fundamental principles of cutting tools. Mixed in with it all there is a great deal of information of value to the journeyman machinist, carpenter and other tradesmen having to do with the use of cutting tools and tools of precision.

PRACTICAL LETTERING. By Thomas F. Meinhardt. 16 pages, 9 x 14 inches bound in paper. Published by Norman W. Henley & Son, New York. Price, 60 cents.

Ths work describes an original system for spacing which results in a superior appearance of lettering, especially when of the block type. Probably all draftsmen have noticed that uniform spacing between block letters does not give a good appearance. For example, the letters H I N in the word "WASHINGTON" will be too close together with a uniform system. Meinhardt's system gives variation in spacing for Gothic style or any variety of plain letters without shade. The height of the letter is divided into 16 parts, and one of these parts is taken as the unit of spacing, the chart giving the number of units to be used between any combination of letters. For example in the word WASHINGTON, instead of using a space between H and I corresponding to the width of the main stem of the I, as would naturally follow with the ordinary system of spacing, the space is made four units or twice the width of the stem. The work is one well worth the attention of those interested in ornamental and practical lettering.

PUNCHES, DIES AND TOOLS FOR MANUFACTURING IN PRESSES. By Joseph V. Woodworth. 483 pages, 6 x 9 inches. 702 illustrations. Published by Norman W. Henley & Son, New York. Price, $4.00.

This work is gotten up in the same style as Mr. Woodworth's former book on dies—"Dies, Their Construction and Use, etc."—and is intended to be a companion and reference volume to accompany same. This book devotes much attention to sub-press work which is coming to be of more and more importance as improved methods of manufacturing such machines as typewriters, computers and similar products are developed. The sub-press principle makes each combination of punch and die a unit which may be brought into use at any time without the need of an expert to set up the press. Its general use tends to greatly simplify press working. A large part of the work has already appeared in the columns of the trade papers, having been contributed by various writers. The work is therefore largely one of compilation, aided by the author's expert knowledge on the subject. The book is timely and is one that should be appreciated by diemakers and others interested in modern methods of interchangeable manufacture of machine parts.

ENGINEERING IN THE UNITED STATES. By Frank Foster. 115 pages, 5¾ x 9 inches. Published by the University Press, Manchester, England.

This book is essentially a report made by Mr. Foster, who was a Gartside Scholar of the University of Manchester. Gartside scholarships were established in 1902, being open to certain university students to enable them to travel abroad and study existing industrial conditions in Germany Switzerland and the United States. This work is an account of Mr. Foster's experience in the United States and is a very readable and interesting work, although few Americans will read it and agree with all that Mr. Foster has said. It strikes one who is well acquainted with American conditions that some of Mr.

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Foster's observations are superficial and in some cases have illustrated what we presume is the traditional British lack of humor, especially when he dilates on the relations of superintendents and their men. However, the work as a whole gives evidence of very careful and systematic investigations of our industrial conditions. The writer not only visited many shops but worked in many as an ordinary workman for wages without favor, hence he was "up against the real thing."

MODERN AMERICAN MACHINE TOOLS. By Prof. C. H. Benjamin, 320 pages, 5½ x 9 inches. 134 illustrations. Published by Archibald Constable & Co., London.

This work was compiled by Prof. Benjamin, of the Case School of Applied Science, Cleveland, Ohio, at the instance of the London publishers, for the purpose of conveniently acquainting Europeans with the general characteristics of the American machine tools. It is consequently gotten up with this in mind and is a sort of amplified catalogue giving features of the various American lathes, planers, radial and upright drills, shapers boring mills, milling machines, gear cutters, grinding machines, key-seaters, punching and shearing machinery, etc., with brief descriptions derived from the author's knowledge and various catalogues, together with what has been published in the technical press. The work is gotten up in fairly good style considering the difficulties of such a work. A compilation of this sort should be of much value to a considerable class, not only abroad but here as well, who are desirous of being posted on the general characteristics of various machine tools and to obtain the matter in convenient form for reference. We should expect that its use in certain engineering schools will follow, where it is desired to give the students an idea of the scope and importance of the modern American machine tool.

UNIVERSAL DICTIONARY OF MECHANICAL DRAWING. By George H. Follows. 60 pages, 8 x 11 inches. 45 cuts. Published by the Engineering News Publishing Co., New York. Price, $1.00 net.

This work was suggested by the author's paper "Mechanical Drawing in the Modern Drafting Room," read before the Engineers' Society of Western Pennsylvania, June, 1902. The paper attracted much attention and resulted in the contribution of a series of articles to the *Engineering News* on mechanical drawing treated as a "language" and presenting the work, in a sense as a drawing dictionary. These articles and some additional matter have been brought together in the present form and treat the subject of drawing and drafting room practice in a manner different from any that has heretofore been employed. It is largely critical, giving examples of bad practice and showing the alternative preferable practice. Many draftsmen will be slow to adopt some of the suggestions for symbols for they would be talking in an unknown language to the shop, and the shop is the place where the drawing is to carry instruction. However, many of the suggestions may be adopted slowly—like simplified spelling. In addition to the general text the work contains considerable data, such as unit chords, weights of round bar per inch of length, dimensions of wrought iron pipe, taps and reamers, stock sizes of machine bolts, examples of the illustrated specification type of drawing, example drawing with bill of material, etc.

NEW TRADE LITERATURE.

FULTON MACHINE AND VISE CO., Lowville, N. Y. Catalogue of the Reed universal, vertical and horizontal swivel vise. The jaws and both swivels are clamped with one operation of the lever.

THE NEW ERA MFG. CO., Kalamazoo, Mich. Booklet, "All About Babbitt Metals," containing valuable information for superintendents and master mechanics on the subject of babbitt metals.

THE CAR INTERCHANGE MANUAL, published by McConway & Torley Co., Pittsburg, Pa., and which was reviewed in the December issue, is sent free on request to those interested. We mentioned the price of 25 cents, but the distribution is free.

INGERSOLL-RAND CO., 11 Broadway, New York. Form X 36 entitled Rand "Imperial," Type 10, Air Compressors giving a detailed description of the more important parts of the compressor and containing many half-tone and sectional drawings of the machine.

T. R. ALMOND MFG. CO., 83 Washington Street, Brooklyn, N. Y. Pamphlet describing Almond adjustable electric lamp fixtures, and telling of some of their varied uses. These fixtures are flexible, being constructed in a way similar to the well known Almond flexible tubing.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J., have published a booklet calling attention to the advantages of Dixon's Ticonderoga flake graphite as a cylinder lubricant for air compressors. Those who are interested in air compressors or drills should obtain a copy.

THE MARK FLATHER PLANER CO., Nashua, N. H. Bulletin No. 7 on Flather planers describing and illustrating the different types. The first page contains a general description of their product, detailed specifications of which will be submitted upon request.

E. W. BLISS CO., 5 Adams Street, Brooklyn, N. Y., 1906 catalogue describing and illustrating the various dies, presses and special machinery built by this company. It contains 578 pages, among which is included an alphabetical index of the subject matter.

GEO. V. CRESSON CO., Philadelphia, Pa., have issued catalogue B for 1906 on power transmitting machinery. It is a cloth-bound book containing 349 pages, including many useful tables and illustrated by excellent engravings. A complete index of the contents is given in back of book.

THE ABRASIVE MATERIAL CO., Philadelphia, Pa. Illustrated catalogue for 1907 of emery and corundum wheels. Descriptions of the product together with price lists are given. The materials used by this company are constantly being tested and thus a high standard of efficiency is maintained.

THE HISEY-WOLF MACHINE CO., Cincinnati, Ohio., have redesigned their line of portable electrical hand drills and have succeeded in reducing the weight of them considerably. This is a very desirable feature in portable tools, as the lighter they are the less they will tire the user in handling them. The company now have in press a new catalogue of their newly designed portable electrically driven drills.

THE BRIDGEPORT SAFETY EMERY WHEEL CO., INC., Bridgeport, Conn. New catalogue for 1907 treating of emery wheels and grinding machinery. The book calls attention to the changes which have been made in their former line of grinding machinery and illustrates other lines recently brought out. A new line of edge and surface grinders is being brought out which is not shown in this issue. Those interested may obtain blueprints and prices upon request.

HEINRICH DREYER, Berlin, Germany. Catalogue (in German) of machine tools and appliances, principally American. This handsomely illustrated catalogue lists and describes Bullard boring mills, Hendey-Norton milling machines, Whitcomb-Blaisdell lathes, Newton milling machines, Cincinnati tool grinders, Morse grinding machines, Garvin vertical milling machines, Hartford automatic screw machines, etc., and several other American machine tools; some foreign machines are also included.

THE REEVES PULLEY CO., Columbus, Indiana, have sent us an impressive list of the large metal working concerns using the Reeves variable speed transmission. These names include The Western Electric Co., Chicago, Ill.; American Tool Works Co., Cincinnati, Ohio; American Car & Foundry Co., Detroit, Mich.; Atlas Engine Works, Indianapolis, Ind.; G. A. Gray Co., Cincinnati, Ohio; Niles Tool Works Co., Hamilton, Ohio; Westinghouse Electric & Mfg. Co., Pittsburg, Pa., and many others.

THE NEW PROCESS RAW HIDE CO., Syracuse, N. Y. Catalogue of raw hide pinions giving a hint of the difference between the "New Process" and other raw hide gears. The catalogue contains a price list of pinions from 2 inches to 15 inches outside diameter and 1 inch to 10 inches face. It also contains a partial list of prominent users of the "New Process" pinions. The catalogue is sent out in a strong manila "wallet" which will be found convenient for carrying papers in the pocket, for which it was designed.

GISHOLT MACHINE CO., Madison, Wis. Catalogue of the Gisholt universal tool grinder and Gisholt lathes and boring mills. This handsomely gotten up piece of advertising literature is principally devoted to the Gisholt grinder illustrating the loss of time and productive effort which follows the old method of each individual machine operator grinding his own tools. It contains a reduced view of the chart which accompanies each Gisholt grinder, showing the correct angles for grinding lathe tools, and other matters of interest to machine shop managers.

MANUFACTURERS' NOTES.

THE WM. W. GANG CO., Cincinnati, Ohio, are making extensions and improvements in their factory which will give them about 3,500 square feet additional floor space.

THE HISEY-WOLF MACHINE CO., Cincinnati O., advise that they have received from Washington a diploma and honorable mention on their exhibit of portable electrical drills and grinders, at the Liege, Belgium exhibition.

THE QUEEN CITY PUNCH AND SHEAR CO. are now located at 208-212 Lawrence St., Cincinnati, O. and will soon be ready with a full line of punches, shears and straightening and bending machines. Mr. C. F. Mayer is president of the company and C. F. Heinss is secretary and treasurer.

THE MUELLER MACHINE TOOL CO., 216 W. Pearl St., Cincinnati, Ohio, have been incorporated, and the company will erect a new and up-to-date machine shop at Colerain Avenue, near Draper Street, to accommodate their increasing business. It is expected that the new shop will be completed some time next spring.

THE International Railway Master Boiler Makers' Association and the Master Steam Boiler Makers' Association meet in joint convention at Cleveland, Ohio, May 21, 22 and 23, 1907, to organize one grand body of foremen boiler makers. Further information may be obtained from the secretary of the latter association, Mr. J. H. Smyth, 284 Totowa Avenue Paterson, N. J.

J. H. WAGENHORST & CO., Youngstown, O., have recently made the following sales of blueprinting machines: Oklahoma City Railway Co., Oklahoma; Ohio State University, Columbus O.; G. D. Peters & Co., Moorgate Works, London, England; Griffin Wheel Co., Chicago, Ill.; Alvey-Ferguson Co., Louisville, Ky.; New England Structural Co., Boston, Mass.; Eugene Dietzgen Co., Chicago, Ill.; American Steam Pump Co., Battle Creek, Mich.

THE BILLINGS & SPENCER CO., Hartford, Conn., have decided to open a Canadian branch for the manufacture of drop forgings and drop forging machinery. It will be known as the Canadian Billings & Spen-